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Aggregate Resources Inventory of Part of Haliburton County Southern Ontario

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Aggregate Resources Inventory Paper 141

By Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey, Ministry of Northern Development and Mines

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Aggregate Resources Inventory of Part of Haliburton County Southern Ontario

By
Staff[1] of the Engineering and Terrain Geology Section

[1]Project Supervisor: I. Szoke; field work and report by G.R. Jones and M.E. Gauvreau; compilation and drafting by Staff of the Aggregate Assessment Office. Assistance with review provided by the Resident Geologists of the Algonquin and Southeastern Districts of the Ministry of Northern Development and Mines. The Staff of the Leslie M. Frost Natural Resources Centre and the Mineral Resources Staff of the Bracebridge, Minden and Bancroft District Offices of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

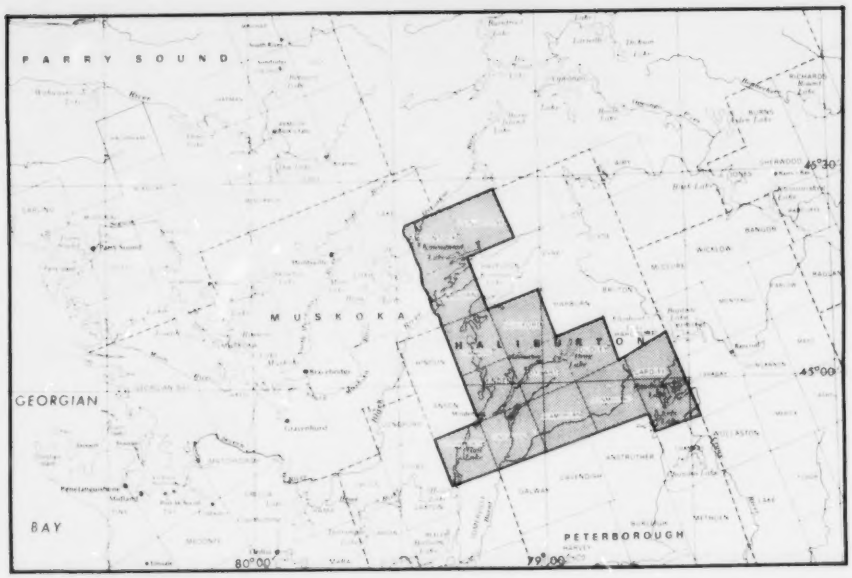


Figure 1. *Key Map Showing Location of the Report Area in Haliburton County. Scale 1:1 584 000.*

This report includes an inventory and evaluation of sand and gravel resources as well as a discussion of bedrock aggregate potential for fourteen townships in Haliburton County, southern Ontario. The report is based on previous studies of the area and a detailed field assessment undertaken in the summer of 1986. The investigation was conducted to delineate and determine the quality and quantity of aggregate within the area to help ensure sufficient aggregate resources are available for future use.

In the project area, 26 areas containing significant amounts of sand and gravel have been selected for possible resource protection at the primary level of significance. They consist largely of outwash, glaciolacustrine delta, subaqueous fan, ice-contact, esker and kame deposits. Selected Sand and Gravel 8 Resource Areas occupy approximately 7500 acres (3050 ha). An estimated 5000 acres (2020 hectares) are currently available for extraction, containing resources of approximately 197 million tons (179 million tonnes). In addition, numerous deposits which add considerably to the resource base of the report area have been classified as resources of secondary significance.

In general, the project area contains adequate resources of low specification aggregate. With the exceptions of Sherborne and Dudley geographic townships and Lutterworth, Glamorgan, and Bicroft Townships, the area contains considerable resources of sandy aggregate. Deposits containing crushable gravel are, however, scarce within the area. The most significant potential sources of this material include outwash features located in Livingstone and McClintock geographic townships and Monmouth Township, along with ice-contact deposits which are scattered throughout the project area.

The aggregate in the report area is generally suitable for most usual applications, however, use of the material in hot-laid asphalt may be restricted in places by the presence of brittle and friable gneiss and schist within the gravel. Gravel from the easternmost townships tends to contain the lowest quantities of these objectionable rock types. In addition, the Ministry of Transportation will not accept local gravel for use in Portland cement concrete which will be exposed to de-icing salts because there is a bonding problem between the aggregate and cement which results in concrete deterioration.

The project area is underlain predominantly by Precambrian bedrock of the Canadian Shield. Recrystallized and deformed gneisses are the most widespread rock type. The bedrock in the area exhibits wide variations with respect to

aggregate quality. Consequently, site specific testing is recommended prior to extraction.

Selected Resource Areas are not meant to be permanent, single land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1986, the total tonnage of mineral aggregates extracted was 136 million tons (123 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Northern Development and Mines, 1988).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of the resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential for bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be neccessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, subsurface materials may be assessed by hand augering and test pitting, supplemented by test hole drilling or excavation, and geophysical surveys using hammer seismic equipment. The symbols for and locations of sample sites, test hole sites, and geophysical traverse lines are noted on Maps 1A, 1B and 1C.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative sections in these deposits are sampled in 25- to 100-pound (11- to 45-kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution, and in some cases the Los Angeles abrasion and impact test, absorption, and Magnesium Sulphate soundness tests and petrographic analyses are carried out. Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey.

The field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Aerial photographs at various scales are used to determine the continuity of deposits, especially in areas where information is limited. Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate deposit thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence.

Topographic maps of the National Topographic System, at a scale of 1:50 000, are used as a compilation base for the field and office data. The information is then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which

accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources (see Glossary, Appendix B) in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976).

Part II — Data Presentation and Interpretation

For each map area there are two maps, each portraying a different aspect of the aggregate resources in the report area. Maps 1A, 1B and 1C, "Distribution of Sand and Gravel Deposits", give a comprehensive inventory of the sand and gravel resources in the report area. Maps 2A, 2B and 2C, "Selected Sand and Gravel Resource Areas", show those deposits which are considered to represent the largest and/or highest quality resources in the area.

MAPS 1A, 1B and 1C : DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

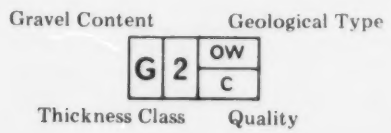
Maps 1A, 1B and 1C are derived from existing surficial geology maps of the area or from aerial photograph interpretation in areas where surficial mapping is incomplete. The maps show the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the maps, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Sand and Gravel pits are identified by a numbered dot on Maps 1A, 1B and 1C and described in Table 2. Each description notes the location and estimated face height of the pit as well as the estimated percentage gravel it contains. Test hole locations appear on Maps 1A, 1B and 1C as a point symbol and are described in Table 4. Geophysics lines are shown on Maps 1A, 1B and 1C by a line symbol and are interpreted in Table 5.

Maps 1A, 1B and 1C also present a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the maps. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Maps 1A, 1B and 1C. These components are illustated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Maps 1A, 1B and 1C.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

MAPS 2A, 2B and 2C: SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 2A, 2B and 2C are interpretative maps derived from an evaluation of the deposits shown on Maps 1A, 1B and 1C. The deposits identified on Maps 2A, 2B and 2C are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is given a deposit number and all such deposits are shown by dark red shading on Maps 2A, 2B and 2C.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units. They represent areas in which a major resource is known to exist, and may be reserved wholly or partially for extractive development and/or resource protection.

Deposits of secondary significance are indicated by light red shading on Maps 2A, 2B and 2C. Such

deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the project area. Generally, deposits in Class 1 (greater than 20 feet (6 m) thick), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in areas with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols on Maps 1A, 1B and 1C. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the quality indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol shows either "C", "O", or "L" or any combination of these indicators, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications (M.T.C.) and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Quality data may also appear in Table 6, where the results of M.T.C. quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendices B and D, respectively.

Analyses of unprocessed samples obtained from test holes, pits or sample sites are plotted on grain size distribution graphs. On the graphs are the Ontario Ministry of Transportation's gradation specification envelopes for aggregate products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product. These graphs, called Aggregate Grading Curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the

basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a project area should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, an area that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Areas with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

BEDROCK RESOURCES

The Precambrian Shield rocks in northern Ontario are generally more complex and variable than the Paleozoic rocks of southern Ontario. They often show wide variations in mineralogy, texture (grain size), joint patterns and degree of weathering, even within specific rock types and over relatively short distances. As these factors are considered important in determining the suitability of the bedrock for use as aggregate, the aggregate potential may also vary considerably from location to location.

Careful selection is especially important if the bedrock is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Fortunately, these chemical reactions should not influence the use of bedrock-derived aggregate for such uses as road-base material. However, highly weathered, very porous and friable rock should be avoided for all uses.

For these reasons, no specific bedrock resources have been selected for resource protection. A summary of the bedrock resources on a regional level is included in the Bedrock Geology and Resource Potential section.

Part III - Assessment of Aggregate Resources in Part of Haliburton County

LOCATION AND POPULATION

The report area includes fourteen townships located within Haliburton County in southern Ontario. The townships occupy approximately 640,000 acres (260 000 ha). Population centres in the area include the communities of Haliburton and Minden. The area is covered by the Coe Hill (31 C/13), Gooderham (31 D/16), Haliburton (31 E/2), Kawagama Lake (31 E/7), Minden (31 D/15) and Wilberforce (31 E/1) map sheets of the National Topographic System, at a scale of 1:50 000.

For the purposes of this report the project area has been subdivided into three separate map areas. The Dorset-Eagle Lake Map Area consists of Livingstone, McClintock, Sherborne and Guilford geographic townships, and Stanhope Township. Minden and Dysart geographic townships, along with Lutterworth, Snowdon and Glamorgan Townships constitute the Haliburton-Minden Map Area. The third map, the Tory Hill-Cardiff Map Area, includes Monmouth, Cardiff and Bicroft Townships, and Dudley geographic township.

The geographic townships located in the project area form portions of larger township municipalities. Sherborne, McClintock and Livingstone geographic townships are part of Sherborne, McClintock, Livingstone, Lawrence and Nightingale Township. Anson, Hindon and Minden Township contains Minden geographic township. Dysart, Dudley and Guilford geographic townships form part of Dysart, Bruton, Clyde, Dudley, Eyre, Guilford, Harburn, Harcourt and Havelock Township.

In 1985, the permanent population of Haliburton County was 11,541 - an increase of approximately 6 percent since 1980 (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Municipal Affairs 1988). Most of this population is concentrated in the communities of Haliburton and Minden which are centres of trade, retail and recreation. Smaller communities in the report area include Dorset, Eagle Lake, Carnarvon, Lutterworth, Gelert, Lochlin, Gooderham, Tory Hill, Wilberforce, Highland Grove and Cardiff. Outside of these communities, a large percentage of the population are rural-residential inhabitants or are engaged in farming. As a result of the scenic beauty of Haliburton County and its close proximity to population centres to the south, the county is a prime tourist area in Ontario. Cottages line the shores of most major lakes and rivers. In addition, the Leslie M. Frost Natural Resources Centre (L.M.F.N.R.C.) and Algonquin, Oxtongue River-Ragged Falls, and Silent Lake Provincial Parks are recreational centres in the area. Estimates of the seasonal population of Haliburton County range from 4 to 10 times the permanent population. Many of the permanent residents are involved in activities supported by the tourism industry.

The combination of a steadily growing permanent population and a large seasonal population has resulted in a strong demand for aggregate in Haliburton County, and this demand may increase in the future. The ongoing construction and maintenance of cottage access roads is partially responsible for the demand. In addition, most of the houses and development within the area are located on valley floors, which coincidentally also contain most of the aggregate resources. These factors may act to restrict the availability of aggregate in some areas. Future residential and related developments may further limit the availability of aggregates for road-building and general construction purposes.

Much of the report area flanks King's Highways 35 and 121, which are major transportation routes in the area. King's Highways 28, 60 and 118, along with Secondary Highways 503, 507 and 648 are also important transportation links. In addition, a network of county and township roads traverses the area.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

Precambrian bedrock underlies the report area, and often occurs at, or just below, the ground surface. The bedrock in the area exhibits the typical "rock knob" or "rock ridge" topography of the Canadian Shield (Mollard 1980; Chapman and Putnam 1984). Glacial and postglacial materials, related to the last major advance and melting of a continental ice sheet during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"), make up the remainder of the land surface.

The glacial and postglacial deposits and the underlying bedrock combine to form two physiographic regions (Chapman and Putnam 1984). Most of the report area is part of the Algonquin Highlands - a large region where bedrock knobs and ridges are interspersed with areas of varying thickness of till or other glacial deposits. A small portion of the Georgian Bay Fringe occurs in the southwestern part of the study area. This physiographic region is characterized by very shallow soil and exposed bedrock.

As glacial ice advanced in a southerly to southwesterly direction over the project area (Henderson 1972, 1973; Finamore and Courtney 1982; Ford and Geddes 1986), a discontinuous cover of till was deposited. This stony, silty sand to sand till generally exists as a thin veneer over bedrock, although in several areas significant thicknesses of till were observed. These thicker till accumulations often flank bedrock knobs or are associated with drumlins. Till is usually not well suited for aggregate use as it often contains excess fines and abundant oversize clasts, however it may be a suitable source of fill in some localities.

The remaining glacial sediments in the area are generally located in bedrock-controlled valleys or depressions. Such is the case with the esker deposits, which form segmented, sinuous ridges of stratified sand and gravel. The eskers appear to have been deposited by meltwaters flowing in tunnels under the ice or in reentrants at the ice front. They trend in a general north to south or northeast to southwest direction, and often rise between 15 and 100 feet (5 and 30 m) above the surrounding terrain. Eskers are important potential sources of crushable gravel in the report area.

Several deposits of undifferentiated ice-contact stratified drift were deposited close to the ice front as

it melted northward. These complex features originated in a variety of depositional environments, and are typified by hummocky topography. Many of the deposits are associated with esker systems. Ice-contact terraces and an end moraine have been identified in Stanhope Township and Guilford geographic township. The terraces were deposited between the ice margin and the side of the Gull River Valley (Kaszycki 1987). The moraine ridge was probably formed during a temporary standstill of the melting ice sheet. Hummocky mounds known as kames were also deposited in close association with glacial ice. These ice-proximal features generally consist of stratified sand and gravel and can exhibit a wide variation in terms of aggregate quality and grain size distribution. Several kames in the report area have been extensively used as aggregate sources. Two kames are situated in Sherborne geographic township.

The outwash features in the report area were deposited by glacial meltwaters flowing in bedrock depressions beyond the ice margin. Major outwash deposits are situated in valleys presently occupied by the Burnt, Irondale and Crowe Rivers as well as Livingstone Creek and Oxtongue Lake (Henderson 1972, 1973; Mollard 1980; Finamore and Courtney 1982; Ford and Geddes 1986; Kaszycki, in preparation). The outwash consists primarily of well stratified and uniformly bedded sand and gravel. Sand is the predominant material exposed in outwash deposits located in the southern part of the project area. Gravel is relatively abundant in deposits within Livingstone and McClintock geographic townships, and in localized areas in the southern part of the report area. Outwash features are the most widespread aggregate deposits in the area and many of these deposits have been traditional aggregate sources.

As the ice front melted back, lower lying areas were inundated by glacial lake waters. These areas include the Gull River Valley and Kashagawigamog Lake (Kaszycki 1985). Subaqueous fans were formed where meltwaters entered the lakes directly from tunnels under the ice (Rust and Romanelli 1975). These lobe- or fan-shaped features consist of variable material ranging from fine sand to coarse gravel. Variable amounts of silt and clay may also be present in these deposits. Where glaciofluvial systems entered the lakes from sources above the water level, broad glaciolacustrine deltas were formed. These deltas are relatively flat features with steep frontal slopes, generally between 10 and 40 feet (3 and 12 m) high. They consist largely of well stratified, gravelly sand. Higher concentrations of gravel are usually available near the surface of the deltas. Numerous pits have been developed in subaqueous fan and deltaic deposits within the report area.

In the deep waters of the glacial lakes, silt and clay were deposited. Glaciolacustrine plain sediments consisting predominantly of silty fine sand were laid down in the shallower parts of the lakes. These glaciolacustrine sands are generally too fine for most aggregate uses except fill. Glaciolacustrine plain sediments are widespread throughout the Gull River Valley.

Erosional activity has been minimal since the disappearance of the ice sheet and lowering of lake waters to present day levels. Organic deposits have been developed in depressions in the land surface, and alluvium has been laid down along the courses of creeks and rivers.

EXTRACTIVE ACTIVITY

Numerous sand and gravel pits have been opened in the report area. The pits are generally widely distributed, although they tend to be more abundant close to highways and population centres. During field investigation, the pits were observed to be at various stages of development. Many of the pits had been worked recently, but several sites had been inactive for a considerable period of time. Crushed stone was actively being extracted from a quarry near the community of Haliburton.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 1A, 1B and 1C for the Dorset-Eagle Lake, Haliburton-Minden and Tory Hill-Cardiff Map Areas, respectively, indicate the deposits which contain granular materials. These deposits occupy a total of approximately 45,500 acres (18 400 ha) and contain an original resource tonnage of 1170 million tons (1060 million tonnes). Many of the deposits have limited potential for extraction because of the restricted amount of, or poor quality of, the available resources they contain, and/or poor resource accessibility. Consequently, only the most significant sources have been suggested for possible resource protection.

The aggregate resources in part of the report area have been previously described by Mollard (1980). The staff of the Leslie M. Frost Natural Resources Centre (L.M.F.N.R.C.) have assessed the aggregate resources within the boundaries of the centre (Van Luit et al., 1984), and much of the information portrayed in this report concerning the resources within the L.M.F.N.R.C. boundaries is based on their work. The information in Appendix E is based directly on data supplied in Van Luit et al. (1984).

Outwash features are widely distributed in the report area and are generally well suited for aggregate extraction. The deposits consist predominantly of well stratified and uniformly bedded sand, although concentrations of crushable gravel may occur in certain localities. Outwash containing crushable gravel is relatively more abundant in deposits within Livingstone and McClintock geographic townships, and Monmouth township. The major factors limiting development in some of the outwash features throughout the report area are high water tables and the presence of silt at depth. Selected Sand and Gravel Resource Areas 1, 3a, 5b, 6b, 7, 11, 19, 21, 22, and 23 consist of outwash sand and gravel.

The ice-contact features, including eskers and kames, also contain valuable resources of sand and gravel. Selected Sand and Gravel Resource Areas 2b, 4, 5a, 12a, 12b, 13, 15c, 15d, 15e, 16, 20a, 20d, 20e, 25b, and 26 consist largely of undifferentiated ice-contact stratified drift. The eskers in Resource Areas

2a, 5a, 9, 12c, 12d, 15a, 15b, 18, 20b, 20c, 24, and 25a are prominent ridges which generally rise between 15 and 100 feet (5 and 30 m) above the surrounding terrain. Two small kame mounds in Sherborne geographic township constitute Resource Areas 6c and 6d. Aggregate of ice-contact origin may show wider variations in grain size than aggregate found in outwash features. Many of the ice-contact deposits are considered important potential sources of crushable gravel.

Several glaciolacustrine features situated within the Gull River valley have been traditional aggregate sources in the area, including the three subaqueous fan deposits which constitute Resource Areas 14 and 17. The fans consist of variably bedded sand and gravel and may contain localized pockets of silt and clay. The aggregate found in the glaciolacustrine delta deposits is generally more uniformly bedded than the subaqueous fan material. Selected Sand and Gravel Resource Area 8 consists of well stratified sand and gravel of deltaic origin.

There are also complex deposits within the study area which exhibit characteristics of both ice-contact and outwash features. Selected Sand and Gravel Resource Area 3b consists of this type of deposit. In addition, the deltaic feature which forms Selected Sand and Gravel Resource Area 10 was deposited in close association with glacial ice and has been designated as an ice-contact delta.

The Selected Sand and Gravel Resource Areas of Primary Significance occupy a total area of 7500 acres (3050 ha). Cultural constraints and previous extraction reduce the area currently available to 5000 acres (2020 ha). The areas contain possible sand and gravel resources of approximately 197 million tons (179 million tonnes).

Many deposits have also been selected at the secondary level of significance. Although these deposits tend to be more limited with respect to extractive potential than the resources selected at the primary level, they add significantly to the resource base of the report area.

With the exception of five townships, the project area is considered to contain adequate resources of low specification aggregate. Aggregate resources are generally lacking in Sherborne and Dudley geographic townships, and Bicroft, Glamorgan and Lutterworth Townships. Elsewhere in the area, sand deposits of outwash and deltaic origin are the main sources of low specification aggregate. Deposits containing good quality crushable gravel are limited in the area. The main sources of this material are outwash features located in Livingstone and McClintock geographic townships and Monmouth Township, as well as ice-contact features scattered throughout the study area.

The aggregate in the report area is generally suitable for most usual applications. In some localities it may contain variable quantities of brittle and friable gneissic rocks which can restrict high specification uses of the aggregate. The Ontario Ministry of Transportation will not use local gravels in Portland cement concrete which will be exposed to de-icing salts because of a bonding problem between the cement and the aggregate.

A. DORSET–EAGLE LAKE MAP AREA

SELECTED SAND AND GRAVEL RESOURCE AREAS (MAP 2A)

Selected Sand and Gravel Resource Area 1

Selected Sand and Gravel Resource Area 1 includes two outwash deposits located in central Livingstone geographic township, along Livingstone Creek. These relatively flat features have been designated as Resource Areas 1a and 1b on Map 2A. Area 1a is the northernmost of these deposits, and two pits have been developed in the area. Faces in pit no. 8 range from 3 to 6 feet (1 to 1.8 m) in height and expose medium to coarse gravel with localized pockets of medium to coarse sand. Coarse gravel with abundant oversize material are revealed in the 10-foot (3 m) faces of pit no. 9. The aggregate exposed in Area 1a appears to be suitable for crushing, although sand control may be necessary in places. Oversize material should be removed, or crushed in a primary crusher. A potentially high water table may limit extraction depth in parts of Area 1a.

Four pits have been opened in Area 1b. Faces in pit nos. 11 and 13 expose 10 feet (3 m) of horizontally bedded, sandy, medium gravel. A sample taken of the material from pit no. 13 contained 55 percent gravel, 44 percent sand and 1 percent fines (Figure 3a). This material appears well suited for the production of a variety of aggregate products including crushed stone. Coarser gravel than is revealed in pit nos. 11 and 13 is exposed in pit nos. 10 and 12. The 10- to 15-foot (3 to 5 m) faces in pit nos. 10 and 12 consist of very coarse gravel with abundant oversize material. A primary crusher would be beneficial for utilizing the oversize clasts. Seismic line HB-GT-3 indicates the presence of the water table 6 feet (1.8 m) below the floor of pit no. 13 (Table 5).

Resource Area 1 occupies 650 acres (265 ha). Cultural constraints and previous extraction reduce the area currently available to 430 acres (174 ha). Assuming average thicknesses of 8 and 12 feet (2 and 4 m) for Areas 1a and 1b, respectively, aggregate resources are estimated to be 10 million tons (9 million tonnes). The resource area is readily accessible by County Road 12 and a gravel-surfaced township road.

Selected Sand and Gravel Resource Area 2

Selected Sand and Gravel Resource Area 2 consists of an esker and an ice-contact deposit. The esker is situated in the western part of Livingstone geographic township and has been designated as Area 2a. It has local relief varying from 30 to 40 feet (9 to 12 m). Test hole HB-TH-2 was excavated in the crest of the ridge. Twelve feet (3.7 m) of interbedded sand and gravel were revealed in the excavation. A sample of this material contained 56 percent gravel, 38 percent sand and 6 percent fines (Figure 5a). The aggregate appears well suited for local use.

Resource Area 2b is an ice-contact ridge located in the northeastern corner of McClintock geographic township. One pit (pit no. 18) has been developed in the deposit and exposes 5 to 15 feet (1.5 to 5 m) of material ranging from sand to coarse gravel. The aggregate is considered suitable for both pit-run and

crusher-run uses. Selective extraction and sand control measures may be required for crushing. Data for seismic lines HB-GT-5 and HB-GT-6 (Table 5) indicate the possibility that aggregate extends to a considerable depth.

Approximately 42 acres (17 ha) are currently available for extraction in Resource Area 2. Assuming average deposit thicknesses of 25 and 30 feet (8 and 9 m) for Areas 2b and 2a, respectively, sand and gravel resources are estimated to be 3 million tons (3 million tonnes). Access to Area 2 is provided by gravel-surfaced cottage and forest access roads.

Selected Sand and Gravel Resource Area 3

Six deposits situated near Oxtongue Lake in the western half of McClintock geographic township have been selected at the primary level of significance. The three northernmost outwash features have been designated as Area 3a. Although fine to coarse gravel is the predominant material exposed on the relatively flat surfaces of these outwash deposits, gravelly sand may be locally abundant. Five pits have been identified in Area 3a. Pit nos. 22, 24 and 25 are gravel sources containing material suitable for uses including granular base course and 16 mm crushed stone. Faces in pit no. 22 are currently slumped and overgrown, but the pit has been extensively used in the past. The Ontario Ministry of Transportation reports that the abundance of sand in sections of the pit has necessitated the use of selection and sand control measures during crushing operations. Faces in pit nos. 24 and 25 expose 5 to 15 feet (1.5 to 5 m) of medium to coarse gravel. The gravel content has been estimated at 50 to 80 percent for these pits. Test holes excavated by the Ontario Ministry of Transportation in the vicinity of both pits indicate that the gravel is generally concentrated in the upper 10 feet (3 m) of the deposit and is underlain predominantly by sand. The water table was encountered in several of the test holes, at depths ranging between 10 and 16 feet (3 and 5 m).

Pit nos. 23 and 26 have also been opened in Area 3a. During field investigation, faces in pit no. 23 were slumped and overgrown. Ontario Ministry of Transportation data for the pit indicate that 5 to 7 feet (1.5 to 2 m) of sand with some gravel overlies till and bedrock. Pit no. 26 is primarily a sand source. Faces in the pit reveal 3 feet (1 m) of fine to medium gravel overlying 12 feet (4 m) of coarse sand.

Area 3b includes the three southernmost deposits. The features have been laid down primarily in an outwash environment, although several ice-contact ridges are also present. Subsurface data is currently lacking for the deposits and boundaries have been based largely on aerial photo interpretation. The outwash material in Area 3b is expected, however, to have similar resource potential as Area 3a. Aggregate within the ice-contact ridges may exhibit greater variation in terms of grain size and quality than the outwash material.

Resource Area 3 occupies 1140 acres (460 ha), of which 860 acres (350 ha) are currently available for extraction. Assuming an average deposit thickness of 12 feet (4 m), sand and gravel resources total approximately 23 million tons (21 million tonnes). Area 3a is accessible via King's Highway 60 and cottage access roads. Area 3b is presently inaccessible by road.

Selected Sand and Gravel Resource Area 4

Selected Sand and Gravel Resource Area 4 includes three ice-contact deposits (Resource Areas 4a to 4c) in southern McClintock geographic township. Area 4a is primarily a sand source containing material suitable for low grade aggregate uses. Subsurface data in Area 4a is provided by two pits, a test hole and a seismic line. In pit no. 31, faces consist of 20 feet (6 m) of medium to coarse sand with occasional silty fine sand layers. Test hole HB-TH-4 uncovered 11.5 feet (3.5 m) of similar material. Results of analysis of samples taken from the pit and test hole indicate that the aggregate may be best suited for use as Granular Base Course (G.B.C.) C and fill (Figures 3a and 5a). Limited amounts of gravel may be available locally from the deposit. Pit no. 32, situated in the eastern part of the deposit, reveals 8 feet (2 m) of gravelly sand. Results from seismic line HB-TH-10 indicate that 23 feet (7 m) of sand may underlie the floor of pit no. 31. Area 4a is considered a significant resource because the local area is lacking readily accessible thick sand deposits.

Pit no. 35 has been opened in the southern part of Area 4b. Faces in the pit expose 10 to 25 feet (3 m to 8 m) of sand with pockets of gravel. This material was sampled and contained 22 percent fine gravel, 77 percent sand and 1 percent fines (Figure 3a). The aggregate in the pit appears well suited for pit-run uses. Fine to coarse gravel was uncovered during excavation of test hole HB-TH-5 in the northern part of the deposit. A sample taken from the test hole contained 66 percent gravel which appears suitable for crushing. Coarse, crushable gravel was also exposed in the 10- to 20-foot (3 to 6 m) faces in pit no. 34.

One pit has been identified in Area 4c (Pit no. 37). Eight feet (2 m) of medium to coarse gravel is exposed in the pit. The gravel is considered suitable for crushing and oversize material should be removed, or crushed in a primary crusher. The depth to bedrock may be variable in the deposit and bedrock was observed on the pit floor.

Resource Area 4 occupies approximately 67 acres (27 ha), of which 51 acres (21 ha) are currently available for extraction. Assuming average deposit thicknesses of 20 feet (6 m) for Areas 4a and 4b, and 10 feet (3 m) for Area 4c, aggregate resources total 1 million tons (1 million tonnes). The deposits are readily accessible by township roads.

Selected Sand and Gravel Resource Area 5

Four deposits which trend northeast to southwest along the southern shore of Kawagama Lake in Sherborne geographic township are included in Selected Sand and Gravel Resource Area 5. The resource area has been subdivided into two areas based on sand and gravel content. Area 5a, considered a potential source of crushable gravel, consists of an esker and an ice-contact deposit. Exposures in the two features reveal predominantly coarse gravel, with abundant

oversize material which could be removed or crushed in a primary crusher.

Area 5b consists of two outwash deposits. Sand is the predominant material exposed at the surface of these deposits. Sand with minor amounts of fine gravel is exposed in the 6- to 20-foot (1.8 to 6m) faces of pit nos. 42 and 43, which have been established in the area. The aggregate in these pits appears suitable for uses including G.B.C. B and C, and fill.

Resource Area 5 occupies 460 acres (186 ha). Cultural constraints and previous extraction reduce the area currently available to 310 acres (125 ha). Assuming an average thickness of 20 feet (6 m), resources of sand and gravel are estimated to be 15 million tons (14 million tonnes). Access to Area 5 is provided by County Road 8. The presence of cottages along Kawagama Lake may inhibit extractive development in parts of Area 5.

Selected Sand and Gravel Resource Area 6

Selected Sand and Gravel Resource Area 6 consists of five deposits situated in Sherborne geographic township. Area 6a includes two ice-contact features located south of Dorset, and contains pit no. 48. Between 10 and 25 feet (3 and 8 m) of variable material ranging from coarse gravel to silty fine sand is exposed in the pit. The material appears well suited for the production of a variety of aggregate products if selective extraction measures are employed. Bedrock is exposed in places within the pit. The depth to bedrock may also be variable in the undeveloped parts of Area 6a. Consequently, subsurface investigation is recommended prior to further extractive development. The Resource Area is well situated with respect to the Dorset market.

An outwash deposit located in central Sherborne geographic township has been designated as Area 6b. Two pits have been developed in this deposit. Five to ten feet (1.5 to 3 m) of sand with some fine gravel is revealed in pit nos. 49 and 50. Test holes HB-TH-6 to HB-TH-9 were excavated either in, or beside, pit no. 49. Between 6.5 and 13 feet (2 and 4 m) of predominantly fine to coarse sand was uncovered in the test holes (Table 5). A sample taken from test hole HB-TH-6 contained 1 percent gravel, 93 percent sand and 6 percent fines (Figure 6a). Test hole HB- TH-9 was excavated adjacent to Pit no. 49 and revealed 5 feet (1.5 m) of sandy gravel over 3 feet (1 m) of sand. The upper gravel unit was sampled and contained 40 percent gravel. In three of the test holes the water table was encountered at depths between 6.5 and 13 feet (2 and 4 m). The deposit is likely best suited for the extraction of pit-run aggregate.

The two kame features which constitute Areas 6c and 6d are located north of St. Nora Lake. Although they are relatively small deposits, the kames are considered important local sources of aggregate in a township where aggregate resources are lacking. Pit no. 52 has been opened in the northernmost kame (Area 6c). Faces in the pit reveal 5 to 15 feet (1.5 to 5 m) of sandy gravel. The material is a potential source of G.B.C. A., although sand control measures may be required during crushing operations. No extractive development has occurred in the southern kame (Area 6d), but a shallow excavation into the deposit uncovered aggregate potentially suitable for G.B.C. B (Appendix E - Figure E10, LF.SS.18).

Resource Area 6 occupies 116 acres (47 ha), of which 110 acres (45 ha) are currently available for extraction. Assuming average deposit thickness values ranging from 12 to 20 feet (4 to 6 m), available sand and gravel resources are estimated to total 3 million tons (3 million tonnes). Gravel-surfaced forest access roads provide access to the resource area.

Selected Sand and Gravel Resource Area 7

Selected Sand and Gravel Resource Area 7 consists of an outwash deposit located in central Stanhope Township, near Halls Lake. Three pits have been identified in the deposit. In pit no. 56, 8 feet (2 m) of fine to coarse gravel overlies 12 feet (4 m) of sand with minor amounts of fine gravel. A sample from the upper gravel unit contained 59 percent gravel (Figure 4a, Pit 56a). The lower sand unit was also sampled and contained 9 percent gravel, 87 percent sand and 4 percent fines (Figure 4a, Pit 56b). Similar material was observed in the 5- to 15-foot (1.5 to 5 m) faces in pit no. 57, although the upper gravel layer is less than 5 feet (1.5 m) thick. Six to ten feet (1.8 to 3 m) of gravelly sand is exposed in pit no. 55. Test hole HB-TH-10 was excavated in the southern part of the deposit and uncovered 10 feet (3 m) of fine to coarse sand over bedrock.

Generally, Area 7 is considered a source of predominantly low specification aggregate suitable for uses including G.B.C. B and C, and fill. Blending would likely be required to produce asphaltic sand products. In addition, selective extraction of gravel suitable for crushing may be possible from gravel layers such as those observed in the upper faces of pit no. 56.

Resource Area 7 totals 205 acres (83 ha), of which 125 acres (51 ha) are currently available for extraction. Assuming an average depth of 20 feet (6 m), sand and gravel resources are estimated to be 6 million tons (5 million tonnes). Excellent access is provided by County Road 13 which branches off King's Highway 35.

Selected Sand and Gravel Resource Area 8

Two glaciolacustrine delta deposits situated between Boshkung and Beech Lakes in Stanhope Township are included in Selected Sand and Gravel Resource Area 8. The northernmost deposit (Area 8a) has been classified as a sand source. Pit nos. 65 and 66, developed in Area 8a, expose between 10 and 35 feet (3 and 11 m) of sand with occasional pockets of gravel. The Ontario Ministry of Transportation reports that products produced from pit no. 65 include G.B.C. B and C, and fill. Limited amounts of crushed stone have also been produced with selective extraction of the gravel pockets found in the pit. The sand fraction of the aggregate requires blending for use in hot-laid asphalt.

The Ontario Ministry of Transportation has excavated nineteen test holes to a depth of 10 feet (3 m) in the southernmost deposit (Area 8b). The aver-

age gravel content in these test holes was approximately 45 percent. Most of the gravel was concentrated in the upper 8 feet (2 m) of the test holes, and was underlain primarily by sand. The aggregate was found to be acceptable for uses including granular base course and 16 mm crushed stone.

Resource Area 8 occupies 135 acres (55 ha). Cultural constraints and previous extraction reduce the area currently available to 65 acres (26 ha). Assuming an average thickness of 20 feet (6 m), resources of sand and gravel are estimated to be 2 million tons (2 million tonnes). Resource Area 8 is readily accessible via King's Highway 35.

Selected Sand and Gravel Resource Area 9

An esker ridge located in southern Stanhope Township constitutes Selected Sand and Gravel Resource Area 9. The ridge exhibits local relief varying from 15 feet (5 m) at its southern end to over 50 feet (15 m) towards the north. A road-side exposure along the southern end of the deposit reveals 15 feet (5 m) of coarse gravel. The material is considered well suited for crushing, and a primary crusher may be beneficial in utilizing the oversize material. The ridge is considered to be a valuable potential source of crushable gravel, particularly as resources of crushable gravel are lacking in the area.

The esker occupies approximately 41 acres (17 ha) presently available for extraction. Assuming an average deposit thickness of 35 feet (11 m), the available aggregate resources are considered to be 4 million tons (4 million tonnes). Resource area 9 is readily accessible via King's Highway 118.

Selected Sand and Gravel Resource Area 10

Selected Sand and Gravel Resource Area 10 is an ice-proximal delta deposit located along the eastern boundary of Stanhope Township. The deposit has a generally uniform surface with the exception of steep slopes present along the edges. Material exposed on the surface of the feature is chiefly sand. Sandy aggregate is also exposed in pits nos. 74 and 75. In these pits, faces consist of between 8 and 25 feet (2 and 8 m) of medium to coarse sand with occasional pockets of gravel. This material appears well suited for pit-run products.

In places, the sand may overlie and mask coarser aggregate. This relationship was observed in pit no. 76. The 10- to 25-foot (3 to 8 m) faces in this pit reveal up to 10 feet (3 m) of silty fine sand overlying variable material ranging from medium sand to coarse gravel. In one face, 15 to 20 feet (5 to 6 m) of medium to coarse gravel is exposed. If selective extraction measures are employed, the aggregate in the pit is considered well suited for the production of a variety of aggregate products, including crushed stone. Further subsurface investigation may reveal additional reserves of gravel in Area 10, especially in the vicinity of pit no. 76.

Area 10 occupies 370 acres (150 ha), of which 295 acres (119 acres) are considered presently available for extraction. Based on an average deposit thickness estimate of 20 feet (6 m), total resource tonnages are 15 million tons (14 million tonnes). Township roads provide access to the resource area.

Selected Sand and Gravel Resource Area 11

Selected Sand and Gravel Resource Area 11 is an outwash deposit located along the Redstone River in Guilford geographic Township. Area 11 contains mainly sand, although small amounts of gravel were observed.

The pits in Area 11 expose 5 to 40 feet (1.5 to 12 m) of predominantly fine to coarse sand overlain by 6 inches to 6 feet (15 cm to 1.8 m) of fine gravel. In pit nos. 92 and 93, in the easternmost part of the deposit, the upper gravel unit is coarser, and ranges from fine to coarse gravel. Although in general the material in Area 11 lacks fines, a silty section occurs in pit no. 87, and should be avoided during extraction. The aggregate in this deposit is likely best suited for pit-run uses. Crushed stone may be produced from pit nos. 92 and 93 with selective extraction of the upper gravel unit and the use of sand control measures.

Resource Area 11 occupies 400 acres (162 ha) of which 275 acres (111 ha) are considered available for extraction. Assuming an average deposit thickness of 20 feet (6 m) for Area 11, available sand and gravel resources are estimated to total 14 million tons (13 million tonnes). Access to the area is provided by County Road 7.

Selected Sand and Gravel Resource Area 12

Selected Sand and Gravel Resource Area 12 is made up of two ice-contact deposits and two esker segments which are labelled 12a to 12d on Map 2A. Area 12 is located along the Redstone River between Coleman Lake and Silverlynn and Pivot Lakes. The ice-contact deposits extend around the shores of the latter two lakes. Area 12 is considered to be an important source of crushable gravel in Guilford geographic township.

Pit no. 94 in Area 12a has 15- to 25-foot (5 to 8 m) faces and has been worked in several levels. The upper 10 to 12 feet (3 to 4 m) of the pit reveals beds of coarse crushable gravel. Similar material is exposed in several road cuts throughout the deposit. The lower 10 to 15 feet (3 to 5 m) consists mainly of sand. The Ontario Ministry of Transportation reports that aggregate from pit no. 94 is suitable for use as G.B.C. A and C, Hot-Laid no. 4 coarse aggregate, and 5/8" type A Crushed Stone. The sand in the pit would require blending for use in hot-laid asphalt. Pit no. 96 reveals 12 to 15 feet (4 to 5 m) of predominantly medium to coarse gravel. The depth of extraction in Area 12a may be restricted in places by bedrock or by a high water table.

Area 12b, to the east of Area 12a, is a thinner deposit. Pit no. 98, a newly opened pit in a 15-foot (5 m) ridge, revealed 70 to 80 percent gravel. Road cuts in this deposit reveal coarse gravel, suitable for crushing. This deposit is expected to be able to produce products similar to those specified for Area 12a, but aggregate quality testing is recommended prior to extraction.

A 25- to 30-foot (8 to 9 m) esker ridge has been designated as Resource Area 12c. Pit no. 97 is located in the ridge, and has 5- to 20-foot (1.5 to 6 m) faces exposing coarse gravel with abundant oversize clasts. Occasional lenses of medium to coarse sand were noted. The aggregate in Area 12c appears suitable for a number of crushed stone products. A primary crusher would be necessary to make use of the oversize.

A 30-foot (9 m) esker ridge has been selected as Area 12d. This unopened deposit has good potential as an aggregate source. It is expected to contain crushable gravel similar to that contained in Area 12c.

Approximately 108 acres (44 hectares) are currently available for extraction in Resource Area 12. Assuming an average depth of 20 feet (6 m) for Area 12a, 15 feet (5 m) for Area 12b, and 25 feet (8 m) for Areas 12c and 12d, aggregate resources are estimated to be 4 million tons (4 million tonnes). Access to the area is provided by a County Road 7.

RESOURCE AREAS OF SECONDARY SIGNIFICANCE (MAP 2A)

A number of outwash sand deposits have been selected at the secondary level of significance in Livingstone geographic township. They include the outwash feature in which pit no. 1 has been developed. Ten feet (3 m) of sand with minor amounts of fine gravel is exposed in the pit. The Ontario Ministry of Transportation reports that this material is acceptable for uses including G.B.C. C and fill. Three outwash sand deposits are located along Troutspawn Lake. Pit no. 4 has been opened in one of these deposits. Faces in the pit consist of 20 feet (6 m) of medium to coarse sand with minor amounts of fine gravel. Material observed on the surface of the deposits varies from sand to sandy gravel and, as indicated by geophysics line HB-GT-2 (Map 1A, Table 5), in certain areas the aggregate may thinly overlie bedrock or till. The outwash deposit in which pit no. 7 has been developed consists of medium to coarse sand. Significant potential resources of sandy aggregate may be available from an outwash deposit situated along the eastern shore of Kawagama Lake. Medium to coarse sand with limited amounts of fine gravel is exposed on the surface of the feature. Information obtained from seismic line HB-GT-4 indicates that 10 feet (3 m) of sand overlies the water table in the central part of the deposit.

Several outwash gravel deposits in Livingstone geographic township have also been selected at the secondary level of significance. One such deposit is located near Parkside Creek in the northern part of the township. Up to 10 feet (3 m) of sandy fine to medium gravel is revealed in roadside exposures within the deposit. The material is likely suitable for pit-run products. Sandy gravel best suited for pit-run uses is also available from the deposits in which pit nos. 6 and 15 have been established. Medium to coarse gravel is exposed in the 5- to 10-foot (1.5 to 3 m) faces of pit nos. 5 and 17. This material appears suitable for crushing. The oversize material in pit no. 5 requires processing for use in aggregate.

An esker ridge located northwest of Wolf Lake in northern Livingstone geographic township is approximately 20 feet (6 m) high and is considered a potential source of crushable gravel. Two ice-contact deposits are associated with the esker ridge. Variable material ranging from sand to coarse gravel is exposed on the surface of these two hummocky features. Similar material may be found in the three ice-contact deposits located immediately to the southwest.

A number of sand outwash deposits have been selected at the secondary level of significance in McClintock geographic township, including a large deposit along the western shore of Oxtongue Lake. Sand with minor amounts of fine gravel is exposed at the surface of this deposit. Similar aggregate is exposed on the surface of a feature in the northeast part of the township. A seismic investigation (HB-GT-7) indicates that 9 feet (2.7 m) of aggregate overlies bedrock in the southern part of the deposit. Pit no. 33 has been developed in a deposit in the southeastern part of the township. Up to 30 feet (9 m) of gravelly fine to coarse sand is revealed in the pit. This material is likely well suited for pit-run uses. Although a significant thickness of aggregate is exposed in the pit, the thickness of available aggregate elsewhere in the deposit is not as great. The outwash adjoining Resource Area 4b has also been classified as a secondary resource. Pit no. 36 and seismic line HB-GT-12 provide subsurface information for the feature. Faces in pit no. 36 consist of 5 to 15 feet (1.5 to 5 m) of predominantly medium to silty fine sand, which is likely most suitable for use as fill because of its excessive fines content. A localized 3- to 5-foot (1 to 1.5 m) thick gravel layer in the pit may be suitable for higher grade aggregate uses if it is selectively extracted. Data from seismic line HB-GT-12 (Table 5) indicate that 17 feet (5.2 m) of sand and gravel overlie bedrock. In parts of the deposit a high water table and/or the presence of silt at depth may limit the depth of extraction. Pit no. 40, located in a sandy outwash deposit along the north shore of Tock Lake, exposes 6 feet (1.8 m) of gravelly medium to coarse sand. The material appears well suited for pit-run uses and similar material may be available from the presently undeveloped parts of the deposit.

Four gravel outwash deposits have been designated as secondary resources in McClintock geographic township. Three of these deposits are located along the shores of Oxtongue Lake. Between 5 and 8 feet (1.5 to 2 m) of medium to coarse gravel is revealed in a road-side exposure within the northernmost of these deposits. Pit no. 27 has been developed in a more southerly deposit along the lake. Five to twelve feet (1.5 to 4 m) of sandy fine to medium gravel is revealed in the pit. This aggregate is likely suited for pit-run uses. Similar material may be available from the outwash deposit located just southwest of the pit. A gravel outwash deposit is also situated near the southern border of the township, along Ashball Lake. Within the deposit, 5 feet (1.5 m) of fine to medium gravel is available from pit no. 39. A high water table within the deposit may limit extraction at depths greater than 5 feet (1.5 m) within the deposit.

An ice-contact gravel deposit is situated along the north shore of Tock Lake in McClintock geo-

graphic township. Up to 8 feet (2 m) of coarse gravel was observed in road-side exposures within the deposit. Finer aggregate is available from the ice-contact feature in which pit no. 38 has been opened. Faces in the pit consist of 10 to 15 feet (3 to 5 m) of mainly medium sand suitable for local uses.

In addition to those secondary deposits in Livingstone and McClintock geographic townships that have been previously described, there are several outwash features for which little data is available. Access to these features is poor and deposit boundaries have been delineated largely through aerial photo interpretation. The deposits have been selected at the secondary level because they may represent valuable future sources of aggregate, especially if activities such as logging are undertaken in the vicinity. Although these deposits have been classified as sand sources, areas underlain by gravel also likely exist.

Thirteen sand outwash deposits have been selected at the secondary level in Sherborne geographic township. Pit no. 44 has been developed in one such deposit located north of White Trout Bay (Kawagama Lake). The 8- to 20-foot (2 to 6 m) faces in the pit consist largely of clean medium sand which is considered suitable for low specification aggregate use. In the southern faces of the pit, however, 8 feet (2 m) of sandy medium gravel which may be suitable for higher grade aggregate uses is exposed. Pit no. 45 has been established in a feature located south of White Trout Bay. Six to ten feet (1.8 to 3 m) of medium to coarse sand with fine gravel is revealed in the pit. Fine to coarse sand is the predominant material observed at the surface at the deposit in which pit no. 47 has been opened. Five feet (1.5 m) of silty fine sand is revealed in the pit. Coarser sand may be available in the undeveloped part of the deposit located north of the pit. A deposit situated just east of Dorset is also a potential sand source. Medium to coarse sand is exposed at the surface of the deposit. Two outwash features are located between Wren Lake and Little Wren Lake along King's Highway 35. Pit no. 51 has been developed in one of these features. Faces in the pit consist of 5 feet (1.5 m) of gravelly sand which is considered well suited for such uses as G.B.C. B and C. The gravel in the pit is generally too fine for crushing. The sand deposit in the southwest corner of the township is a potential source of low specification aggregate, as are deposits located near Nunikani and Red Pine dams along the Kennisis River system, and a deposit along the southern shore of Kawagama Lake (LF-SS-3, LF-SS-25, LFSS-26, Figures E1 and E12, Appendix E).

Ten gravel outwash deposits have been designated as secondary resources in Sherborne geographic township. They include the five features located between Minden Bay of Kawagama Lake, and Raven Lake. Gravel is the predominent material exposed at the surface of these deposits. Sand also occurs at the surface in places and may also underlie the gravel at depth. These deposits are considered to be potential sources of at least pit-run aggregate. The five remaining features are small deposits located in the eastern part of the township. The two northernmost of these deposits are potential sources of G.B.C. A (LF-SS-4, LF-SS-5; Figures E2 and E3, Appendix E). A number of test holes were excavated by the staff of Leslie M. Frost Natural Resources Centre, in the deposit north of Wolfsbane Lake (LF-SS-4a, 4b, 4c, Figure E2, Appendix E). At least 10 feet (3 m) of clean, good quality gravel was uncovered in these excavations. The water table was encountered at depths between 1 and 3 feet (0.3 and 1 m) in the test holes, and may limit extractive potential. The two deposits located east and west of Mooney Lake and the feature at Red Pine Dam are potential sources of G.B.C. B (LF-SS-8, LF-SS-7, LF-SS-27; Figures E4, E9 and E12, Appendix E). Approximately 7 feet (2 m) of aggregate overlies bedrock in the deposit west of Mooney Lake.

An ice-contact feature is located east of pit no. 51 in western Sherborne geographic township. A 3-foot (1 m) test pit was excavated on the crest of a 15-foot (5 m) ridge within the deposit. Medium to coarse gravel was uncovered in the pit and the material was potentially suitable for crushing. A deltaic deposit is situated along the north shore of St. Nora Lake in Sherborne geographic township. In the western arm of the deposit, a 3-foot (1 m) deep test pit was excavated, exposing 2.5 feet (0.8 m) of silty fine sand overlying good quality, sandy gravel. Elsewhere in the deposit gravelly sand was encountered at the surface. The deltaic aggregate is probably underlain by fine material at depth because silt and clay are exposed along the shore of the lake. A variable bedrock surface may limit extraction in parts of the deposit.

Five outwash deposits have been classified as secondary resources in Stanhope Township. Sand outwash features are located along the shores of Cat and Big Hawk Lakes. Samples taken from these two deposits by the staff of the L.M.F.N.R.C. were acceptable for use as G.B.C. B (LF-SS-36, LF-SS-40; Figures E15 and E16, Appendix E). The outwash deposit along the north shore of Big Brother Lake was also sampled and found to be acceptable for use as G.B.C. B (LF-SS-33, LF-SS-34, Figures E14 and E15, Appendix E). A gravel outwash feature adjoins the northern part of Resource Area 7. Pit no. 54 has been excavated in the deposit. Ten to fifteen feet (3 to 5 m) of medium to coarse gravel is exposed in the pit. The Ontario Ministry of Transportation has excavated several test holes in the vicinity of the pit. The test holes uncovered 10 feet (3 m) of predominantly coarse gravel with abundant oversize material. The depth of extraction in parts of the deposit may be limited by a potentially high water table. The remaining outwash deposit selected at the secondary level in the township is situated south of Resource Area 7. Subsurface information for the deposit is provided by a pit and test hole. In pit no. 58, 2 feet (0.6 m) of sandy fine gravel overlies 3 to 6 feet (1 to 2 m) of medium sand. Test hole HB-TH-11 uncovered 12.5 feet (3.8 m) of gravelly sand over the water table. This material was sampled and contained 23 percent gravel, 76 percent sand and 1 percent fines (Figure 7a). The most readily produced aggregate products from the deposit likely include G.B.C. B and C, and fill.

Two glaciolacustrine delta deposits have been traditional sources of aggregate in Stanhope Township. Pits nos. 63 and 64 have been identified in the

delta situated along Boshkung Lake. Faces in the pits range from 10 to 20 feet (3 to 6 m) high and consist of sand with minor amounts of fine gravel. A sample from pit no. 64 contained 20 percent gravel and 80 percent sand (Figure 4a). The deltaic material is generally acceptable for uses including G.B.C. B and C, and fill. Crushed stone has been produced from the pits, but the pits are presently depleted of crushable gravel. The second delta is located at Carnarvon along the southern border of the township. One pit (pit no. 67) has been excavated in the deposit within Stanhope Township. Faces in the pit consist of 8 to 10 feet (2 to 3 m) of medium sand suitable for low specification aggregate uses.

Two outwash-glaciolacustrine plain deposits are located near Beech Lake in Stanhope Township. Between 5 and 10 feet (1.5 and 3 m) of medium to coarse sand with minor amounts of fine gravel is exposed in pit nos. 71 and 72, which have been developed in the deposits. The deposits appear well suited for extraction of low specification aggregate. Additional quantities of low grade aggregate may be available from an ice-contact sand deposit situated southwest of Halls Lake and another located just north of Resource Area 10.

Flanking Resource Area 9 in southern Stanhope Township are two ice-contact deposits. They are hummocky features which contain several swampy depressions. Material exposed at the surface of the deposits ranges from sand to coarse gravel, and in places bedrock is close to the surface. Two pits have been opened in the deposits in the township. Pit no. 68 has been depleted of most aggregate resources and bedrock is exposed in pit faces. Five feet (1.5 m) of sandy fine to coarse gravel is revealed in pit no. 69. Test hole HB-TH-12 uncovered 6.5 feet (2.0 m) of gravelly sand over bedrock. Thicker ridges and hummocks within the deposits may be best suited for extraction. A variety of aggregate products, including crushed stone, may be produced from the deposits. Another potential source of crushable gravel is the ice-contact feature located along the shore of Second Lake. Coarse gravel is exposed on the surface of the deposit, but further subsurface investigation is required to test the quality of the aggregate at depth.

Three ice-contact terrace features and an end moraine are situated along the boundary between Stanhope Township and Guilford geographic township. Three pits have been identified in the ice-contact terrace deposit located north of the moraine. Pit nos. 80 and 81 consist of 10 to 20 feet (3 to 6 m) of sand with localized pockets of fine to medium gravel. The Ontario Ministry of Transportation has excavated several test holes in the vicinity of these pits. The test holes uncovered up to 18 feet (5 m) of sand similar to that exposed in the pits. Silt seams were abundant in some test holes. The material revealed in the pits and test holes is considered best suited for uses including G.B.C. C and fill. Crushed stone has been produced from a gravel pocket in pit no. 81, and subsurface investigation in the undeveloped parts of the deposit may uncover additional reserves of gravel. Subsurface data is lacking for the two ice-contact terrace features south of the moraine (pit no. 78). A shallow test pit was dug in the westernmost terrace revealing 3 feet (1 m) of gravelly sand. One pit has been opened in the end moraine. Between 8 and 18 feet (2 and 5 m) of predominantly sandy aggregate with occasional boulders is exposed in the pit.

A number of deposits in Guilford geographic township have been selected at the secondary level of significance. There is no subsurface information available for the five outwash deposits and an esker located north of Redstone Lake, and access is limited. Pit run and fill are probably the most readily available products which can be extracted from these deposits, although pockets of coarser material may also be present. Further subsurface investigation of these deposits is required.

In an outwash deposit east of Guilford Lake, pit no. 113 reveals 4 to 6 feet (1.2 to 1.8 m) of sand and fine gravel. Pit no. 109, in an outwash deposit north of Bushwolf Lake, has 6- to 8-foot (1.8 to 2 m) faces, containing 20 to 40 percent fine to coarse gravel in a fine to medium sand matrix. A minor amount of oversize clasts were noted in the upper 2 to 4 feet (0.6 to 1.2 m), and in a pocket in the north face. Aggregate from both these deposits is suitable for use as pit-run material. High water tables may limit the depth of extraction in these deposits.

Four ice-contact deposits lie north of the Redstone River. Pit no. 84 has been developed in the westernmost deposit and exposes 15 to 30 feet (5 to 9 m) of medium to coarse sand. Fine to medium gravel is contained in the upper 3 feet (1 m) of the pit. Pit no. 85 in a 25-foot (8 m) ridge has 10- to 12-foot (3 to 4 m) faces. In the upper 2 to 5 feet (0.6 to 1.5 m) fine to coarse gravel was noted. Below this, the material consisted of medium to coarse sand. The two unopened deposits are expected to contain similar material. These four ice-contact ridges have good potential as sources of pit-run aggregate. Small amounts of crushable gravel would be available with selective extraction of the seams and pockets of coarser material.

Several delta deposits in Guilford geographic township show potential as aggregate sources. Pit no. 105, located in a delta west of Eagle Lake, contains 12 to 15 feet (4 to 5 m) of gravelly sand. Pit no. 107 reveals 10 to 30 feet (3 to 9 m) of predominantly medium sand interbedded with silty seams. The upper 1 to 4 feet (0.3 to 1.2 m) of the face contains fine to medium gravel. One large silty pocket would have to be avoided during extraction. Pit no. 108 contains a greater amount of gravel. The upper half of the 10- to 20-foot (3 to 6 m) faces contains coarse gravel, suitable for crushing. The lower part of the pit contains fine sand. In general, the material in this deposit appears suitable for pit-run uses. Selective extraction of the upper, coarser beds could provide crushable gravel. Pit nos. 101, 102 and 103 have been developed in the delta south of Cranberry Lake. The 5- to 30-foot (1.5 to 9 m) faces in pit nos. 102 and 103 reveal 3 to 6 feet (1 to 1.8 m) of medium to coarse gravel in a medium to coarse sand matrix over fine to medium sand. Occasional thin beds of gravel were noted in the sand. Exposure in pit no. 101 was poor because the 20- to 30-foot (6 to 9 m) faces had been graded. North of Green Lake, pit no. 82 reveals 10 feet (3 m) of fine to silty fine sand. Pit no. 83

exposes less than 5 feet (less than 1.5 m) of coarse sand with a trace of fine gravel. Aggregate from these two deltas is suitable for pit-run uses and fill. Although there are no exposures at the present time in the delta deposits north of the Redstone River, the material is expected to be similar to that in the other delta deposits in Guilford geographic township.

B. HALIBURTON–MINDEN MAP AREA

SELECTED SAND AND GRAVEL RESOURCE AREAS (MAP 2B)

Selected Sand and Gravel Resource Area 13

Selected Sand and Gravel Resource Area 13 consists of five ice-contact deposits situated in northwestern Minden geographic township. The deposits have been designated Areas 13a to 13d on Map 2B. Pit no. 116 has been developed in Area 13a. The 30- to 35-foot (9 to 11 m) faces in the pit reveal coarse gravel with abundant cobbles and boulders. The material appears well suited for crushing. Oversize clasts should be removed or crushed in a primary crusher. Similar quality gravel may be available from the presently undeveloped parts of Area 13a.

Area 13b is considered primarily a sand source. Faces in pit no. 117 consist of 20 to 30 feet (6 to 9 m) of fine to medium sand. The sand is likely suitable for low specification aggregates such as G.B.C. C and fill.

Two pits have been identified in the southernmost deposit in Area 13c. Ten feet (3 m) of medium to coarse gravel is exposed in pit no. 121. This material was sampled and contained 67 percent gravel (Figure 8a). The gravel is considered well suited for crushing. Finer aggregate is revealed in the 5- to 15-foot (1.5 to 5 m) faces of pit no. 120. The gravel content of the pit has been estimated at 30 to 45 percent. The material is considered best suited for pit-run because gravel in the crushable size range is lacking. Limited amounts of crushed stone may be produced, however, with selective extraction of gravel pockets in the eastern faces of the pit. Seismic line HBGT-20 indicates the presence of the water table 4 feet (1.2 m) below the floor of pit no. 120. The northernmost deposit in Area 13c is considered to have comparable resource potential to that described for the southernmost deposit.

Pit no. 123 has been opened in the hummocky ice-contact feature which constitutes Area 13d. The 10- to 17-foot (3 to 5 m) faces in the pit consist of variable material ranging from sand to coarse gravel. The Ontario Ministry of Transportation reports that aggregate extracted from the pit is acceptable for uses including 16 mm crushed stone and granular base course. Higher quality uses of the coarse aggregate, such as asphaltic stone, may be restricted because of excessive amounts of friable gneissic rock within the gravel. The sand fraction of the aggregate requires blending for use as asphaltic sand.

Resource Area 13 occupies 305 acres (123 ha), of which 260 acres (105 ha) are currently available for extraction. Assuming average deposit thicknesses of 15 and 25 feet (5 and 8 m), available aggregate resources are estimated to be 13 million tons (12 million tonnes). With the exception of the northern deposit in Area 13c, the resource area is readily accessible by roads branching off King's Highways 35 and 118.

Selected Sand and Gravel Resource Area 14

Two subaqueous fan deposits located along the western boundary of Minden geographic township have been selected at the primary level of significance. Pit no. 126 has been excavated into the ridge which forms Area 14a. Between 10 and 20 feet (3 and 6 m) of medium to coarse gravel is revealed in the pit. The gravel appears well suited for crushing. Abundant oversize material was observed in the pit and this material should be removed or crushed in a primary crusher. Up to 6 feet (2 m) of silt and clay overlie the aggregate in the western faces of the pit. This fine sediment should be removed prior to extraction to avoid contamination of the underlying aggregate.

Sand is the predominant material revealed on the surface of Area 14b. This sand may overlie coarser aggregate in certain areas as indicated by faces in pit no. 127. In one face in the pit, 1 to 3 feet (0.3 to 1 m) of sand overlies up to 14 feet (4 m) of fine to coarse gravel. The gravel content in this face has been estimated at 40 to 50 percent. In another face in the pit, 5 to 10 feet (1.5 to 3 m) of very fine sand overlies medium to coarse sand with approximately 20 percent fine gravel. A variety of road-building and general construction aggregate could be produced from the pit, with selective extraction procedures.

Resource Area 14 totals 130 acres (53 ha). Cultural constraints and previous extraction reduce the area currently available to 95 acres (38 ha). Assuming an average deposit thickness of 20 feet (6 m), sand and gravel resources are approximately 4 million tons (4 million tonnes). The resource area is readily accessible by township roads.

Selected Sand and Gravel Resource Area 15

Five esker ridges and six associated ice-contact deposits located in the eastern parts of Minden geographic township and Snowdon Township make up Selected Sand and Gravel Resource Area 15. Three pits have been identified in the eskers which have been designated Areas 15a and 15b. Faces in pit no. 160 consist of 40 feet (12 m) of variable material ranging from sand to coarse gravel. The gravel content in the pit has been estimated to be between 35 and 70 percent. Faces in pit no. 159 are up to 25 feet (8 m) high and contain approximately 60 to 70 percent gravel. Pit no. 158 was being developed at the time of the field investigation. At the site, coarse gravel and boulders were observed on the surface of the 10- to 15-foot (3 to 5 m) high esker ridge. The eskers are considered to be valuable potential sources of crushable gravel. Oversize material is abundant in Area 15b and should be removed or processed.

The southernmost ice-contact deposit has been designated as Area 15c. Several ridges in excess of 30 feet (9 m) high exist in the deposit. Pit nos. 231 to 233 have been developed in these ridges. Medium to coarse gravel with localized sand pockets is exposed

in the 10- to 40-foot (3 to 12 m) faces in pit no. 233. This material was sampled and contained 60 percent gravel, 38 percent sand and 2 percent fines (Figure 10a). Eight to twenty feet (2 to 6 m) of aggregate ranging from sand to coarse gravel is revealed in pit nos. 231 and 232. In general, the deposit appears well suited for extraction of both crusher-run and pitrun aggregates.

Subsurface data for the ice-contact features which constitute Areas 15d and 15e is provided by three pits. In pit no. 161, 25 to 30 feet (8 to 9 m) of variable material ranging from sand to coarse gravel is exposed. Between 40 to 60 percent gravel was observed in the 5-foot (1.5 m) faces in pit no. 157. Ten to forty-five feet (3 to 14 m) of medium to coarse gravel is revealed in pit no. 228. Pit no. 228 has been excavated in a high ridge in which aggregate resources are nearing depletion. Based on existing pit data, Areas 15d and 15e are likely suitable for extraction of a variety of road-building and construction aggregates including crushed stone.

Resource Area 15 occupies approximately 390 acres (158 ha), of which 335 acres (136 ha) are presently available for extraction. Assuming average deposit thickness values ranging from 12 to 30 feet (4 to 9 m), available aggregate resources are estimated to total 13 million tons (12 million tonnes). County Roads 1, 17 and 18, and the township roads which branch off them, provide access to Resource Area 15.

Selected Sand and Gravel Resource Area 16

Three ice-contact deposits south of Drag Lake in eastern Dysart geographic township have been selected at the primary level of significance. These deposits have been traditional sources of a variety of aggregate products.

Area 16a has been classified as a gravel deposit. The faces in pit no. 193 reveal 8 to 30 feet (2 to 9 m) of coarse gravel with an appreciable amount of oversize clasts. A sample taken from the pit contained 36 percent gravel, 62 percent sand and 2 percent fines (Figure 9a). Although this particular sample is not suitable for crushing, overall the pit is considered to be a crushable source based on its extractive history. The Ontario Ministry of Transportation reports that northwest of pit no. 193 the gravel is of insufficient quality to produce H.L. 4 coarse aggregate and 16 mm crushed type "A". However, the aggregate in Area 16 appears suitable for lower specification crushable products, including granular base course. Area 16a represents an important source of crushable gravel because coarse aggregate resources in Dysart geographic township are limited.

The material in Area 16b appears to be predominantly sand. Pit nos. 192 and 194 reveal 10 to 15 feet (3 to 5 m) of mainly sand with beds of gravel and some silty seams. Ontario Ministry of Transportation data indicates that crushable gravel is located behind the northeast face of pit no. 194. In the past, this deposit has produced G.B.C. A, B, and C, 5/8" type A and B Crushed Stone, and Hot-Laid no. 4 fine and coarse aggregate.

At the time of field investigation, no pits had been developed in Area 16c. Soil probes revealed gravelly sand, suitable for pit-run uses. Pockets or seams of coarser material may also be present.

Resource Area 16 occupies 196 acres (79 ha), of which 112 acres (45 ha) are considered available for extraction. Assuming an average deposit thickness of 20 feet (6 m) for Areas 16a, 16b and 16c, available resources are estimated to total 6 million tons (5 million tonnes). The area is readily accessible via gravel roads running north from King's Highway 121.

Selected Sand and Gravel Resource Area 17

Selected Sand and Gravel Resource Area 17 is a subaqueous fan deposit located in northeastern Lutterworth Township. Pit nos. 203 and 204 provide subsurface data for the feature. Faces in pit no. 204 range from 35 to 50 feet (11 to 15 m) high. In one section of the pit, 35 feet (11 m) of sand with approximately 10 percent gravel is revealed. Twenty feet (6 m) of inter-bedded sand and gravel overlie 25 feet (8 m) of coarse gravel in another section of the pit. The Ontario Ministry of Transportation reports that the aggregate in the pit is acceptable for uses including asphaltic stone and granular base course. Sand control would be required in sections for crushing, and a lack of fines to ensure proper compaction may be a problem for production of G.B.C. C. Ten feet (3 m) of coarse crushable gravel was observed in pit no. 203.

Resource Area 17 represents a valuable potential source of sand and gravel within a township which is generally deficient in aggregate. It occupies approximately 17 acres (7 ha) which are considered currently available for extraction. Assuming an average deposit thickness of 35 feet (11 m), aggregate resources total an estimated 1 million tons (1 million tonnes). Road access is excellent to the resource area.

Selected Sand and Gravel Resource Area 18

An esker ridge in northwestern Snowdon Township constitutes Selected Sand and Gravel Resource Area 18. The ridge rises generally between 15 and 30 feet (5 and 9 m) above the surrounding terrain. Pit no. 225 has been excavated into the ridge, and pit faces consist of 5 to 20 feet (1.5 to 6 m) of coarse gravel with abundant oversize material. The aggregate is suitable for crushing and a primary crusher may be beneficial for processing of oversize clasts. Ontario Ministry of Transportation data indicate that products including asphaltic stone and granular base course have been produced from the material in the pit. Similar quality aggregate is available from pit no. 226.

The esker occupies 70 acres (28 ha), of which 62 acres (25 ha) are currently available for extraction. Assuming the esker averages 20 feet (6 m) in thickness, sand and gravel resources are estimated to be 3 million tons (3 million tonnes). Excellent access to Resource Area 18 is provided by County Road 16.

Selected Sand and Gravel Resource Area 19

Eleven outwash deposits situated along the Burnt River in Snowdon Township have been selected at the primary level of significance. The deposits have a generally uniform surface, with the exception of steep terraces which are often present along the edges. Area 19a is the northernmost feature. Pit nos. 235 to 237 have been identified in this area, and expose between 5 and 10 feet (1.5 and 3 m) of predominantly fine to coarse sand. Low specification aggregates such as G.B.C. C and fill are likely the most readily produced materials from the deposit. Silt seams were observed in pit no. 237 and should be avoided during extraction. Silt was also uncovered in test holes excavated by the Ontario Ministry of Transportation in the vicinity of pit nos. 235 and 237. The silt layers were over 2 feet (0.6 m) thick in some holes and were encountered at depths between 4 and 12 feet (1.2 and 4 m). In addition to sand, limited amounts of crushable gravel may be available from localized areas in the deposit. In test holes excavated by the Ontario Ministry of Transportation east of pit no. 236, 8 to 12 feet (2 to 4 m) of gravel was uncovered.

A terrace up to 60 feet (18 m) high marks the western boundary of the northern deposit in Area 19b. Faces in pit no. 241 have been excavated into the side of this terrace. The faces consist of 30 to 40 feet (9 to 12 m) of predominantly medium sand. Coarse sand with minor amounts of fine gravel are exposed in the upper 3 feet (1 m) of the pit faces. Sand was also observed on the surface of the deposit. The sand is considered well suited for use in low specification aggregate products. The southern deposit in Area 19b is likely to have similar resource potential.

The remaining deposits in the resource area have been designated as Areas 19c and 19d. Pit no. 220 has been opened in Area 19c. Fifteen feet (5 m) of sand with minor amounts of fine gravel is exposed in the pit. This material is likely suitable for uses including G.B.C. B and C, and fill. Subsurface data for Area 19d is lacking and deposit boundaries have been delineated by aerial photo interpretation. Based on data for similar features in the resource area, significant resources of at least low specification aggregate may be available from these deposits.

Resource Area 19 totals 435 acres (176 ha), of which 390 acres (158 ha) are currently available for extraction. Assuming average deposit thicknesses ranging from 12 to 30 feet (4 to 9 m), available sand and gravel resources are estimated to total 17 million tons (15 million tonnes). With the exception of Area 19d, the resource area is readily accessible by road.

Selected Sand and Gravel Resource Area 20

Selected Sand and Gravel Resource Area 20 consists of three ice-contact deposits and two esker ridges in central Snowdon Township. Pit no. 238 provides subsurface information for the northern ice-contact deposit (Area 20a). Faces in the pit reveal 5 to 10 feet (1.5 to 3 m) of coarse gravel. The gravel is considered crushable and a primary crusher would be beneficial to process the oversize material. The esker ridges (Areas 20b and 20c) are also considered potential sources of crushable gravel. Coarse gravel was observed in an 8-foot (2 m) road-side exposure in Area 20c and was also encountered on the surface of the eskers. The ridges have local relief varying from 15 to 40 feet (5 to 12 m). Gravel-surfaced township roads provide access to Areas 20a and 20c.

Subsurface information for the two southern ice-contact features (Areas 20d and 20e) is provided by pit no. 243 and several test holes excavated by the Ontario Ministry of Transportation. Ontario Ministry of Transportation data indicates that the gravel available from the 25-foot (8 m) faces in the pit is suitable for uses including Hot-Laid No. 4 stone, 16 mm crushed stone and granular base course. Test holes excavated in Area 20e uncovered 10 feet (3 m) of sand containing approximately 25 to 30 percent gravel. This material appears well suited for pit-run uses. The location of the deposit east of the Burnt River may inhibit extraction as road access presently stops at the river's east bank.

Resource Area 20 occupies approximately 54 acres (22 ha) currently available for extraction. Assuming deposit thickness values ranging from 12 to 30 feet (4 to 9 m), resources total an estimated 1 million tons (1 million tonnes).

RESOURCE AREAS OF SECONDARY SIGNIFICANCE (MAP 2B)

Nine outwash deposits have been selected at the secondary level of significance in Minden geographic township. Uniformly bedded, medium gravel was observed in pits and road-side exposures within the deposit located east of Twelve Mile Lake. Although the gravel is considered crushable, a potentially high water table may limit the depth of extraction in the deposit. During field investigation, water was present on the floor of pit no. 141. Coarse aggregate may also be available from two features situated west of Mountain Lake. Road-side exposures in these deposits consist of 5 to 6 feet (1.5 to 2 m) of sandy, fine to coarse gravel. A potentially high water table may also limit the amount of aggregate available from these deposits. The remaining outwash features in the township are primarily sources of sand suitable for low specification aggregate uses. Pit nos. 147 to 149 have been identified in the deposits located near Soyers Lake. Between 5 and 10 feet (1.5 and 3 m) of fine to coarse sand is exposed in the pits. Silt seams, present in the faces of pit no. 149, should be avoided during extraction. Sand is exposed on the surface of the deposits situated near the north shore of Duck Lake and west of Mountain Lake.

Several ice-contact features, as well as a small esker ridge, have also been classified as secondary resources in Minden geographic township. Two ice-contact features and the esker ridge are situated along the northern boundary of the township, east of Carnarvon. The deposits extend northward into Stanhope Township (Map 2A) where they have also been selected for possible resource protection. They are expected to contain similar quality aggregate as described for those features in Stanhope Township. Aggregate suitable for products including granular base course and 16 mm crushed stone have been extracted from pit no. 144, developed in the eastern-

most deposit. During field investigation, crushing and screening equipment were operating in pit no. 143 at Carnarvon. Variable material ranging from fine sand with silt and clay seams to coarse gravel was evident in the pit. Three ice-contact features found south of Area 13d, and a fourth located west of Area 13a, are potential sources of at least low specification aggregate products. Limited amounts of gravel suitable for local use may be available from the two ice-contact deposits which lie south of Area 13c. Three pits have been identified in the deposit situated along Horseshoe Lake. In pit nos. 134 and 135, between 8 and 25 feet (2 and 8 m) of predominantly fine to coarse sand is exposed. A 2-foot (0.6 m) thick coarse gravel layer exists in pit no. 135 and pockets of till are common in pit no. 134. Five to fifteen feet (1.5 to 5 m) of gravelly sand suitable for pit-run uses is revealed in pit no. 136.

Significant resources of at least low specification aggregate are available from four glaciolacustrine delta deposits in Minden geographic township. Pit no. 142 has been excavated into the delta located at Carnarvon. Two feet (0.6 m) of gravelly medium to coarse sand overlies 3 to 8 feet (1 to 2 m) of fine to medium sand in the pit. Coarser aggregate may be available from the delta situated along the eastern shore of Twelve Mile Lake. Ten feet (3 m) of medium to coarse gravel overlies 10 feet (3 m) of sand in one face of pit no. 139. Pit no. 153 has been established in a delta situated between Duck and Horseshoe Lakes. Five feet (1.5 m) of coarse sand with minor amounts of fine gravel overlies steeply inclined layers of fine to medium sand in the pit. This aggregate appears well suited for local pit-run uses. Material exposed on the surface of the delta situated along Minden Lake consists chiefly of fine to medium sand. Similar material is revealed in the 5- to 10-foot (1.5 to 3 m) faces of pit no. 130. Silt seams up to one half inch (1.3 cm) thick are interbedded with the sand in the pit. The aggregate in the southern part of the delta tends to be finer and roadside exposures consist largely of interbedded fine sand and silt.

Additional quantities of at least low specification aggregate may be available from the outwash-delta deposit which lies near the western boundary of Minden geographic township. Exposures of sand are common on the surface of the deposit. Two pits have been excavated into an ice-contact delta at Ingoldsby. In pit no. 155, 4 to 15 feet (1.2 to 5 m) of fine to coarse sand of deltaic origin is revealed. Between 5 to 15 feet (1.5 and 5 m) of ice-contact material, varying from fine sand to coarse gravel, is exposed in pit no. 156. Although a considerable amount of material has been removed from the deposit, the remaining aggregate is considered well suited for local uses.

Six deposits in Dysart geographic township have been selected as secondary resource areas, including an ice-contact deposit along King's Highway 121 on the north shore of Kashagawigamog Lake. Pit no. 165 exposes 5 to 20 feet (1.5 to 6 m) of variable material. One face contained medium sand whereas another face contained coarse gravel. The aggregate in pit no. 165 appears suitable for pit-run uses. A small amount of crushable gravel may be removed if selective extraction and sand control measures are used. A glaciolacustrine delta located between King's Highway 121 and Kashagawigamog Lake is a sand source. Pit no. 163 reveals 15 to 20 feet (5 to 6 m) of predominantly fine sand. Up to 3 feet (1 m) of medium to coarse sand with fine to medium gravel overlies the sand. The Ontario Ministry of Transportation reports that material from this deposit has been used in the past for G.B.C. C. The depth of extraction may be limited by a high water table. South of Drag Lake, an ice-contact deposit which may contain material suitable for pit-run uses similar to that observed in Selected Sand and Gravel Resource Area 16b, has also been designated as a secondary deposit. No subsurface data is presently available for this deposit, and detailed testing should be undertaken prior to extraction.

In eastern Dysart geographic township three outwash deposits have also been selected. Pit nos. 183 to 189, and 191 expose predominantly sand with beds or pockets of gravel. This material is suitable for pit-run uses. Pit no. 195, developed in the easternmost outwash deposit, reveals 5 to 8 feet (1.5 to 2 m) of fine to coarse gravel which may yield small quantities of crushable gravel.

The deposits selected at the secondary level of significance in Lutterworth Township are primarily sources of low specification aggregate. They include four subaqueous fan features located along the eastern edge of the Gull River valley, south of Gull Lake. Pit nos. 199 and 200 have been opened in one of these deposits. Between 4 and 15 feet (1.2 and 5 m) of largely fine to medium sand is exposed in the pits. Gravel pockets were observed beneath the sand in places within pit no. 200, and the Ontario Ministry of Transportation reports objectionable quantities of silt exist in the vicinity of the pit. Only limited amounts of aggregate are currently available in the fan deposit in which pit nos. 197 and 198 have been excavated, because of previous extraction. The remaining material in the deposit is considered, however, well suited for local pit-run uses. Sand is exposed at the surface of the fan deposit situated just south of pit no. 197. In the southernmost fan, between 10 and 20 feet (3 and 6 m) of predominantly fine to coarse sand is exposed in pit no. 196. Localized pockets of gravel which may be suitable for crushing with selective extraction and sand control, also exist within the sand.

A broad glaciolacustrine delta located at Lutterworth has been a traditional source of sand in Lutterworth Township. Between 5 and 20 feet (1.5 and 6 m) of largely fine to coarse sand is exposed in nine pits opened in the delta. The material is considered best suited for such uses as G.B.C. C and fill. The three outwash features in the southeast corner of Lutterworth Township are also primarily sand sources. Sand with minor amounts of fine gravel is revealed in the 3- to 13-foot (1 to 4 m) faces in pit nos. 215 and 216. In pit nos. 217 and 218, faces consist of 8 to 20 feet (2 to 6 m) of fine to medium sand. Sand suitable for local use may also be available from the 8- to 10-foot (2 to 3 m) faces in pit no. 201. This pit has been opened in an outwash-glaciolacustrine plain deposit located in the north-central part of Lutterworth Township.

An esker ridge located along South Lake in Snowdon Township has been classified as a secondary resource. The ridge rises 20 feet (6 m) above the surrounding terrain. A 3-foot (1 m) deep test pit, excavated in the crest of the ridge, uncovered sandy fine to coarse gravel which appears suitable for crushing. A number of ice-contact deposits, including a small esker, have also been selected at the secondary level in Snowdon Township. These deposits are associated with Resource Areas 15 and 18. They are hummocky features which contain numerous swampy depressions. Material exposed at the surface of these deposits ranges from sand to coarse gravel and, in places, bedrock is close to the surface. Because of the variable nature of these deposits, detailed subsurface investigation is required to identify areas best suited for extractive development.

Several outwash deposits have been selected at the secondary level along the Burnt River in Snowdon Township. In general, they are sand sources suitable for the extraction of low specification aggregate products. Pit nos. 219, 221, 230 and 244 reveal between 5 and 30 feet (1.5 and 9 m) of sand. Coarser aggregate may be available, however, from the deposits in which pit nos. 239 and 240 have been developed. Faces in these pits consist of 5 to 7 feet (1.5 to 2 m) of sandy gravel. The major factor limiting extraction in some of these deposits is a potentially high water table. Silt may also be encountered at depth within the features.

The remaining deposits selected at the secondary level in Snowdon Township are outwash features located along the Irondale River. Faces in pit nos. 247, 249, 250 and 251 range from 10 to 20 feet (3 to 6 m) and consist of sand. The sand is generally suitable for uses including G.B.C. C and fill. Localized pockets of gravel were observed within mainly sandy aggregate in pit nos. 245 and 248. Within those deposits designated as thickness class 3 (5 to 10 feet thick), a potentially high water table may limit extraction in certain areas. Silt may also be encountered within the deposits, especially at depth.

The outwash deposits along the Irondale River in Glamorgan Township have been selected as secondary resources. Several pits have been developed in these deposits. Pit nos. 253 to 256, 262, 264, and 266 to 268 reveal 4 to 20 feet (1.2 to 6 m) of mainly sand with some seams or pockets of fine to medium gravel. A sample from pit no. 256 contained 19 percent gravel and 81 percent sand (Figure 10a). The Ontario Ministry of Transportation reports that aggregate from pit nos. 253, 255, 256 and 267 is suitable for G.B.C. B and C, provided selective extraction measures are used. As well, the sand is suitable for use in hot-laid asphalt if it is blended to the required gradation. In general the aggregate in the Irondale River outwash appears acceptable for pit-run uses and fill. The depth of extraction may be limited by a high water table as water was noted on the floors of pit nos. 262 and 267, or by bedrock, such as in pit nos. 262 and 264.

Outwash deposits along Laronde Creek in Glamorgan Township have also been selected at the secondary level. Pit no. 270 reveals 10 to 12 feet (3 to 4 m) of gravelly sand. A sample of this material contained 18 percent gravel and 82 percent sand. Aggregate was being extracted from this pit at the time of field investigation. The undeveloped deposits along the creek are expected to contain similar material. These outwash deposits could potentially provide a significant amount of pit-run aggregate.

C. TORY HILL–CARDIFF MAP AREA

SELECTED SAND AND GRAVEL RESOURCE AREAS (MAP 2C)

Selected Sand and Gravel Resource Area 21

Selected Sand and Gravel Resource Area 21 is an outwash deposit located along the Little Drag River north of Drag Lake in Dudley geographic township. Area 21 has been selected as a primary resource area because it represents a large source of pit-run material in a township which is otherwise deficient in aggregate. Pit no. 275 reveals 10 to 15 feet (3 to 5 m) of sand. An 8- to 12-inch (20 to 30 cm) thick silty layer was noted in the pit. Pit nos. 273 and 274 contain 6 to 10 feet (1.8 to 3 m) of medium to coarse sand with minor amounts of fine gravel. The aggregate in these pits is considered suitable for pit-run uses. Seismic line HB-GT-26 indicates that the depth of extraction in pit no. 273 may be limited by a high water table (Table 5).

Approximately 154 acres (62 ha) are currently available for extraction in Resource Area 21. Assuming an average depth of 10 feet (3 m), aggregate resources are estimated to be 4 million tons (4 million tonnes). Access to the area is provided by a gravel road which branches off County Road 19.

Selected Sand and Gravel Resource Area 22

Another two outwash deposits in Dudley geographic township have been selected at the primary level of significance. Selected Sand and Gravel Resource Area 22 is located at the northwestern tip of Grace Lake. The 10- to 15-foot (3 to 5 m) faces in pit no. 280 contain aggregate with a gravel content of approximately 20 percent. Sand was observed in several road cuts in this deposit. The aggregate in the deposit appears suitable for pit-run purposes.

Resource Area 22 contains 265 acres (107 ha) of sand and gravel of which 189 acres (76 ha) are considered available for extraction. Assuming an average depth of 12 feet (4 m), aggregate resources are estimated to be 6 million tons (5 million tonnes). Access to Area 22 is provided by County Road 15.

Selected Sand and Gravel Resource Area 23

Selected Sand and Gravel Resource Area 23 consists of five outwash deposits situated along the Irondale River in northern Cardiff Township and in Monmouth Township. These deposits contain large potential resources of sand and gravel and have been traditional sources of aggregate in the area.

Areas 23a and 23b have been designated as sand deposits, although pockets of gravel were observed in all five deposits. In area 23a, north of Pusey Lake in Cardiff Township, pit nos. 311, 312 and 313 expose 5 to 30 feet (1.5 to 9 m) of fine to coarse sand with beds of fine to medium gravel. This

material is suitable for use as pit-run aggregate. Coarser gravel beds were noted in pit nos. 312 and 313. A sample from pit no. 312 contained 48 percent gravel, 51 percent sand, and 1 percent fines (Figure 12a). Pits nos. 301 to 306 in Area 23b in Monmouth Township expose predominantly gravelly sand suitable for pit-run purposes. Pockets of crushable aggregate were observed in pit nos. 301, 305 and 306. A sample from a gravel pocket in pit no. 301 contained 56 percent gravel, 42 percent sand and 2 percent fines (Figure 12a), whereas a sample from pit no. 306 contained 48 percent gravel and 52 percent sand (Figure 12a). The Ontario Ministry of Transportation reports that in Area 23b, selective extraction of these coarse gravel pockets is necessary in order to produce crushed stone products.

Area 23c also contains mainly sandy gravel. Some coarser gravel beds, suitable for crushing, were observed in pit no. 296 and a sample from this section of the pit contained 53 percent gravel, 45 percent sand and 2 percent fines (Figure 12a). Pit no. 295 revealed 5 to 6 feet (1.5 to 1.8 m) of predominantly sand. Seismic line HB-GT-29 (Table 5) indicates the presence of sand and gravel to a minimum depth of 40 feet (12.2 m). Selected Resource Area 23c is expected to be a source of pit-run aggregate and, with processing, possibly higher specification aggregate.

In pit nos. 289 and 290 in Area 23d, 4 to 12 feet (1.2 to 4 m) of fine to coarse gravel was noted. The Ontario Ministry of Transportation reports that sand control may be required during crushing operations in certain parts of these pits. Area 23e also contains crushable gravel. Pit no. 288 has 6- to 15-foot (1.8 to 5 m) faces containing 40 to 55 percent medium to coarse gravel. The Ontario Ministry of Transportation states that aggregate from this pit has been used in the past for G.B.C. B, and that selection and sand control measures may be necessary in order to produce crushed stone products. Water and/or bedrock, encountered at a depth of approximately 20 feet (6 m) in Ontario Ministry of Transportation test holes in Area 23e, may limit the depth of extraction.

Resource Area 23 occupies approximately 960 acres (390 ha) in Cardiff and Monmouth Townships, of which 380 acres (154 ha) are considered available for extraction. Assuming an average deposit thickness of 15 feet (5 m) for Areas 23a, 23b, 23c and 23e, and of 12 feet (4 m) for Area 23d, available resources are estimated to total 14 million tons (13 million tonnes). The area is readily accessible via gravel roads which branch off King's Highways 121 and 648.

Selected Sand and Gravel Resource Area 24

Selected Sand and Gravel Resource Area 24 is an esker located north of the Irondale River in southwestern Monmouth Township. Although no subsurface information is available for this deposit, it has been selected on the basis of its expected geological characteristics (see Appendix C). The esker may contain large resources of sand and gravel suitable for a range of uses. Testing to determine the quality and quantity of the granular material is recommended prior to extractive development.

Selected Sand and Gravel Resource Area 24 occupies 17 acres (7 hectares), all of which is considered to be presently available for extraction. Assuming an average deposit thickness of 30 feet (9 m), available resources are estimated to be 1 million tons (1 million tonnes). At the time of investigation, road access to the selected resource area was not available.

Selected Sand and Gravel Resource Area 25

Selected Sand and Gravel Resource Area 25 consists of an esker and an ice-contact deposit, labelled 25a and 25b respectively on Map 2C. These deposits are important sources of crushable gravel in the township. Area 25 is located in northern Cardiff Township, south of the hamlet of Harcourt.

At the time of field investigation no pits had been developed in Area 25a. Road cuts along the esker revealed coarse gravel, suitable for use in producing crushed stone products. The rest of Area 25a may contain similar material, however aggregate quality testing is recommended prior to development for extraction.

Pit no. 316 in Area 25b has 15- to 25-foot (5 to 8 m) faces, exposing 30 to 50 percent medium to coarse gravel. The Ontario Ministry of Transportation reports that sand control would be required during crushing operations in this pit. Pit no. 317 reveals 30 feet (9 m) of sand and gravel. One large pocket of crushable gravel was noted in the upper 15 feet (5 m) of the face. The rest of the pit face contained predominantly medium sand. The sand and gravel in Area 25b appears suitable for pit-run uses, and for crushable purposes if selective extraction and sand control measures are used.

Resource Area 25 occupies 190 acres (77 ha). Cultural setbacks and previous extraction reduce the area currently available to 119 acres (48 ha). Assuming an average deposit thickness of 30 feet (9 m) for Area 25a and 25 feet (8 m) for Area 25b, available resources are estimated to be 7 million tons (6 million tonnes). Access to the area is provided by King's Highway 648.

Selected Sand and Gravel Resource Area 26

Selected Sand and Gravel Resource Area 26 is located near Highland Grove in northeastern Cardiff Township. This selected area is made up of two deposits. The first, labelled Area 26a on Map 2C, is an ice-contact terrace deposit which flanks bedrock and consists predominantly of gravel. The second deposit, Area 26b, is an ice-contact deposit. The aggregate from Area 26 can be used in a variety of products.

Although Selected Area 26a has been classed as a gravel deposit, it contains a range of materials. Five pits have been developed in Area 26a. Pit no. 321 exposes 10 to 20 feet (3 to 6 m) of mainly fine to coarse sand. Silty seams are present throughout the pit and a small amount of fine gravel was also noted. Bedrock was exposed in one face. In pit no. 322, face heights ranged from 20 to 30 feet (6 to 9 m). The faces contained fine to coarse sand with seams of fine gravel. Minor silt seams less than 1 inch (2.5

cm) thick were noted. Pit no. 323 contained 10 to 15 feet (3 to 5 m) of fine to medium sand with minor fine to coarse gravel. Aggregate from pit nos. 321, 322 and 323 is suitable for pit-run uses. Pit nos. 324 and 325 have faces which reach up to 40 feet (12 m) in height and which expose 40 to 60 percent gravel in a matrix of medium to coarse sand. A large amount of oversize material was observed in both pits. A primary crusher would be required to make use of this oversize material. In pit no. 324, a pocket of till-like material was noted, and would have to be avoided during extraction. In one area of pit no. 325, the gravel was coated with clay. This material would require washing prior to crushing. Ontario Ministry of Transportation data indicate that aggregate from these pits has been used for G.B.C. A.

Area 26b also contains variable material but has been classified as a sand deposit. Pit no. 326 contains 6 to 20 feet (1.8 to 6 m) of fine to silty fine sand, which would be suitable for fill. Two distinct areas have been worked in pit no. 327. The most southerly area has 6- to 10-foot (1.8 to 3 m) faces exposing 30 to 40 percent fine to coarse gravel in a medium sand matrix. The bedding is variable, and a pocket of fine to silty fine sand was noted. The northernmost section has 6- to 25-foot (1.8 to 8 m) faces, containing 20 to 30 percent fine to coarse gravel in a fine to silty fine sand matrix, with an appreciable oversize component. The aggregate in pit no. 327 is suitable for pit-run uses, and for crushing if selective extraction and sand control measures are used. The Ontario Ministry of Transportation reports that aggregate from pit no. 327 has been used in the past to produce G.B.C. A. With blending, the sand would be suitable for hot-laid asphalt production.

Approximately 99 acres (40 hectares) are currently available for extraction in Resource Area 26. Assuming an average depth of 40 feet (12 m) for Area 26a and 20 feet (6 m) for Area 26b, aggregate resources are estimated to be 7 million tons (6 million tonnes). The area is readily accessible via King's Highway 648.

RESOURCE AREAS OF SECONDARY SIGNIFICANCE (MAP 2C)

Two outwash deposits in Dudley geographic township have been selected at the secondary level of significance. One deposit is adjacent to the northern project area boundary. Two pits have been identified in the deposit but access was not available at the time of field investigation. The deposit has good potential as an aggregate source and further investigation is required. The other outwash deposit is located west of South Portage Lake. Road cuts in the deposit exposed sand and gravel. It is expected that this deposit contains material similar to that found in the outwash deposits in the southeast corner of neighbouring Dysart geographic township. The deposits in Dysart geographic township contain material suitable for use in pit-run products, and may contain limited amounts of crushable aggregate.

A number of outwash deposits located along the Irondale River in Monmouth and Cardiff Townships have also been designated as secondary areas. Some of these deposits contain pits, whereas other deposits were undeveloped at the time of field investigation. Two outwash deposits located north of Wilbermere Lake along the township boundary were investigated by the Ontario Ministry of Transportation (pit no. 331 is located in the northernmost of these deposits). Test holes showed approximately 12 feet (4 m) of aggregate, limited by water or bedrock. The material is mainly sand, with one pocket of gravel, and occasional boulders were noted. The sand requires blending for use in hot-laid asphalt products.

In a small deposit southwest of Wilbermere Lake, the 10-foot (3 m) faces of pit no. 300 revealed medium to coarse gravel in coarse sand. Pit no. 299 was developed in another small deposit to the south, and contained 5 to 20 feet (1.5 to 6 m) of medium sand with minor boulders. Fine to coarse gravel was present in the top foot (0.3 m) of the face. Ontario Ministry of Transportation data indicates that the sand grades from acceptable to fine for hot-laid asphalt products.

Three pits have been opened in a deposit further south along the Irondale River. Pit no. 292 contained 4 to 5 feet (1.2 to 1.5 m) of medium sand. The 5- to 6-foot (1.5 to 1.8 m) faces in pit no. 293 revealed medium sand with minor coarse gravel. Information on file with the Ontario Ministry of Transportation indicates that the sand would require blending in order to be used in hot-laid asphalt. Pit no. 294 contained 3 to 5 feet (1 to 1.5 m) of interbedded coarse sand and fine gravel. In an adjacent deposit, pit no. 291 contained 5- to 7-foot (1.5 to 2 m) faces exposing medium to coarse sand with a trace of fine to medium gravel. Seismic line HB-GT-28 indicates 11 feet (3.4 m) of aggregate over bedrock (Table 5). Test hole HB-GT-16, excavated south of pit no. 291, revealed 3.5 feet (1.1 m) of clean fine to medium sand over 2 feet (0.6 m) of silty fine sand over 6.5 feet (2 m) of clean coarse sand.

Pit no. 285 has been opened in a deposit near the border between Monmouth and Glamorgan Townships. It contains 4 to 6 feet (1.2 to 1.8 m) of fine to medium sand. Seismic line HB-GT-27 was carried out in the pit and the results indicate that 8 feet (2.4 m) of dry sand and gravel overlie wet sand and gravel to a depth of 40 feet (12.2 m). Test hole HB-TH-15 was excavated nearby and exposed 5.5 feet (1.7 m) of clean fine to coarse sand with trace coarse gravel over 6.5 feet (2.0 m) of fine sand grading downwards into silty sand.

In general, aggregate in the deposits selected at the secondary level along the Irondale River appears suitable for use in pit-run products. The undeveloped deposits flanking the Irondale River are expected to contain similar material.

Two outwash deposits lie along Cope Creek near the Monmouth-Cardiff border. Pit no. 298, with 4- to 12-foot (1.2 to 4 m) faces, has been developed in one of the deposits. The aggregate varies from less than 5 percent gravel in the western part of the pit to 40 percent in the easternmost part. According to Ontario Ministry of Transportation information this area of the pit can produce G.B.C. A, provided sand control measures are used. The sand in the finer portions of the pit grades coarse for hot-laid asphalt products and would require blending in order to be

used. Ontario Ministry of Transportation test holes indicate that the water table limits the depth of extraction in this deposit to approximately 17 feet (5.2 m). Pit no. 297 has been developed in the other outwash deposit. The 5- to 12-foot (1.5 to 4 m) faces reveal fine to coarse sand with approximately 10 percent fine gravel. Minor thin silty seams were noted. The aggregate appears suitable for pit-run purposes.

The Ontario Ministry of Transportation has investigated the outwash southwest of Hadlington Lake in southwestern Monmouth Township. Test holes revealed 30 to 50 percent gravel, and ranged from 10 to 12 feet (3 to 4 m) in depth. One hole was limited to a depth of 5 feet (1.5 m) by bedrock. The aggregate is suitable for G.B.C. B and C. Sand control would be required in order to produce G.B.C. A and 5/8 inch crushed stone. Blending would be necessary in order for the sand to be used in hot-laid asphaltic products.

Two unopened outwash deposits near Hadlington Creek may contain aggregate similar to that found in the outwash deposits along the Irondale River near Hadlington Lake. Further testing is recommended to establish the quality and quantity of the aggregate prior to extraction from these deposits.

Pit no. 286 has been developed in an ice-contact deposit located west of Lower Monmouth Lake in southern Monmouth Township. This pit exposed 6 to 10 feet (1.8 to 3 m) of medium sand with minor clasts ranging in size from fine gravel to boulders. Aggregate in pit no. 286 appears suitable for pit-run purposes. This deposit is an important source of pit-run aggregate in the southern part of Monmouth Township.

Seven outwash deposits (excluding those along the western township boundary), five ice-contact deposits, and an esker have been selected at the secondary level of significance in Cardiff Township. Three outwash deposits were undeveloped at the time of field investigation. Hand augering in a 10- to 15-foot (3 to 5 m) ridge north of Hudson Lake revealed gravelly sand. In a deposit east of Jordan Lake, close to the Cardiff Township border, gravelly sand was noted in road cuts. A pit located beyond the township border contained 15 to 20 feet (5 to 6 m) of gravelly sand. An unopened deposit south of Jordan Lake is thought to contain similar material. Three outwash gravel deposits are located between Deer Lake and Highland Grove. Pit no. 328, located in the southernmost deposit, has 5- to 6-foot (1.5 to 1.8 m) faces containing fine to coarse gravel in a loamy medium sand matrix. The 5- to 8-foot (1.5 to 2 m) faces in pit no. 329 reveal 2 feet (0.6 m) of medium sand over fine to medium gravel in a medium sand matrix. Minor oversize clasts were noted in both pits. Ontario Ministry of Transportation data indicates that aggregate from pit no. 329 is suitable for G.B.C. A, provided strict sand control measures are used. Material of similar quality is expected to exist in the more northerly deposits. Pit no. 358 has been opened in an outwash deposit on the shore of Inlet Bay on Paudash Lake. The 3- to 8-foot (1 to 2 m) faces contain medium to coarse sand with minor fine to coarse gravel.

Pit no. 318 is located in an ice-contact deposit east of Hudson Lake, and at the time of investigation had 5- to 10-foot (1.5 to 3 m) faces revealing 1 to 3 feet (0.3 to 1 m) of gravel over bedded sand. Bedrock was exposed in the pit face. Four- to twelve-foot (1.2 to 4 m) faces have been developed in pit no. 319 in a deposit northwest of Highland Grove. The faces consist of fine to coarse gravel in a medium to coarse sand matrix. Minor beds of medium to coarse sand were also noted, as were approximately 5 percent oversize clasts. Water was present on the pit floor. Ontario Ministry of Transportation data indicate that the aggregate could be used for G.B.C. A if sand control measures are used. A 5- to 10-foot (1.5 to 3 m) exposure in a 40-foot (12 m) ridge west of Highland Grove contained mainly sand. Minor silt seams, till pockets, and boulders were noted. Three pits have been developed in an ice-contact deposit on the western shore of Paudash Lake. Pit no. 350 has 20- to 30-foot (6 to 9 m) faces revealing coarse sand with minor fine to medium gravel. Pit no. 348 has 10- to 20-foot (3 to 6 m) faces and contains silty fine to coarse sand with minor fine to coarse gravel. Minor oversize clasts were noted. A 6- to 12-inch (15 cm to 30 cm) thick silt seam runs throughout the pit. Ontario Ministry of Transportation data indicates that sand from this pit is suitable for H.L. No. 4 asphalt and has been used in the past for sand cushion. Several road cuts in the deposit exposed 4 to 8 feet (1.2 to 2 m) of sand. Pit no. 355 has been developed in a deposit on the east side of Paudash Lake. The 10- to 12-foot (3 to 4 m) faces expose fine to coarse gravel in a medium to coarse sand matrix. However, test holes excavated by the Ontario Ministry of Transportation indicate sand to a depth of 11 feet (3.4 m). An esker south of Jordan Lake has also been selected. Twenty- to thirty-foot exposures in the deposit, and the faces in pit no. 330, showed gravelly sand. In general, the deposits selected as secondary resource areas in Cardiff Township are important sources of pit-run aggregate. Crushable gravel may also exist in isolated pockets.

BEDROCK GEOLOGY AND RESOURCE POTENTIAL

The bedrock in the report area is part of the Grenville Province of the Canadian Precambrian Shield. The rocks of Middle to Late Precambrian age in the report area can be subdivided into two major lithotectonic terranes (Wynne-Edwards 1972). The northern part of the study area is underlain by bedrock of the Central Gneiss Belt. The predominant rock types within this belt are highly deformed, commonly interlayered quartzofeldspathic and mafic gneisses of indeterminate origin. The southern part of the project area is underlain by rocks of the Central Metasedimentary Belt. A variety of metasedimentary, metavolcanic and igneous rock types are included within this southern belt.

In general, the bedrock geology of the area is extremely complex. Metamorphic and deformational processes are the main causes of this complexity (Marmont and Johnston 1987). The bedrock geology of the area is portrayed at a reconnaissance level in Figure 2. Geological mapping and reports by Satterly

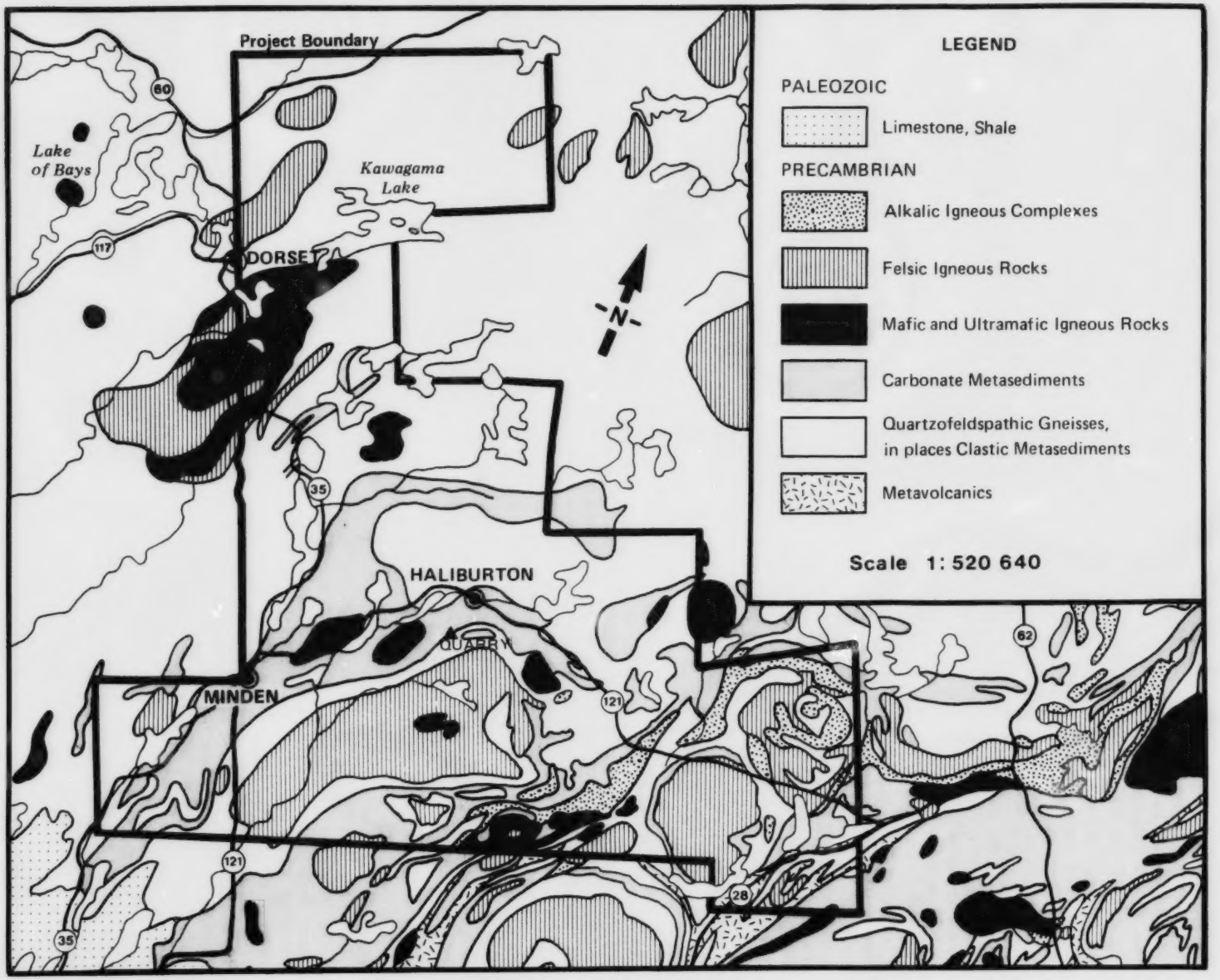


FIGURE 2: BEDROCK GEOLOGY OF PART OF HALIBURTON COUNTY Modified after Lumbers (1979)

(1943), Armstrong (1970), Armstrong and Gittins (1968, 1970), Davidson et al. (1979), Lumbers (1979), Davidson and Morgan (1981), Culshaw et al. (1983), Martin (1983), Culshaw (1986), Easton (1986, 1987a, 1987b) and Bright (1987a, 1987b) cover portions of the project area. Much of the northern part of the report area has not been mapped in detail.

Banded pink quartzofeldspathic, in places clastic metasedimentary gneisses are the most widespread rock type within the project area. The clastic metasediments, which are not shown separately in Figure 2, occur mainly in the Central Metasedimentary Belt, in the southern part of the area. Pink gneissic rocks are common within many of the other map units portrayed in Figure 2. The gneisses in the area vary widely in respect to their weathering characteristics and their suitability for use as aggregate.

Several belts of carbonate metasedimentary rock are situated in the southern part of the report area, within the Central Metasedimentary Belt. Marble is a common variety of carbonate metasedimentary rock. Felsic igneous rocks consist predominantly of granitic to granodioritic and tonalitic massive to gneissic units. Large bodies of these rock types occur in Snowdon, Glamorgan, Monmouth and Cardiff Townships. Bodies of mafic and ultramafic rock are scattered throughout the report area. These bodies are generally small in size, with the exception of a large area in Sherborne geographic township. Rock types which form these bodies include diorite, gabbro, anorthosite and derived gneisses. Rocks of the alkalic igneous complexes commonly form thin belts in the southern part of the report area. They consist largely of massive to layered syenite and nepheline syenite gneisses. A few small areas in the southeastern part of the study area are underlain by mafic metavolcanic rocks.

The bedrock within the project area may exhibit wide variations with respect to aggregate quality over relatively short distances. Consequently, any site proposed for quarry development should be tested in detail before extraction occurs. Highly weathered, brittle and friable bedrock which is unacceptable for aggregate use is common within the report area. There are also many areas underlain by more massive-looking, hard and durable rock which appears suitable for a variety of aggregate applications. However, some of the massive coarse grained felsic igneous rocks and quartzofeldspathic gneisses with high mica, feldspar and quartz contents may have bonding problems because the smooth cleavage and fracture surfaces of these minerals hinder the adhesion of asphalt and cement mixes. This problem may be circumvented by weathering the rocks for a period of time in stockpiles or by adding chemicals which erode the smooth surfaces and allow better adhesion. Rogers (1985) reports that some granitic rocks can slowly react with the alkalies from portland cement concrete, resulting in concrete deterioration. Radioactive mineralization may also occur locally within some rock types in the area and these should be avoided during extraction.

Bedrock is actively being extracted from one quarry in the report area for the production of aggregate. The quarry, located just south of the community of Haliburton in Dysart geographic township (see Figure 2), has been established in highly deformed bedrock consisting mainly of dark amphibolite with subordinate interlayers of pink gneissic and minor granitic rock. Faces in the quarry range from 25 to 50 feet (8 to 15 m) high. The rock appears suitable for most usual aggregate applications including granular base course, 16 mm crushed stone and asphaltic stone. The bedrock in which the quarry has been developed may locally contain some radioactive mineralization in the granitic interlayers.

Satterly (1943) reports the existence of three quarries in Minden geographic township which have been used for aggregate purposes. These quarries were developed in pink gneiss, anorthosite and marble, and are presently abandoned. Several quarries in the project area have been developed for uses other than for aggregate. Many of these quarries have been established as sources of building stone. In addition, a quarry in Guilford geographic township has been established in recrystallized white dolomite, and quartzite containing thin, white diopside-rich interlayers of these units (Hewitt 1964). This material is extracted for uses including terrazo chips, aquarium sand, poultry grit and driveway surfacing.

Within the report area, considerable latitude exists in choosing sites for potential bedrock extraction as extensive areas occur in which bedrock is exposed at the surface or is covered by thin drift. Excessive thicknesses of overburden which would restrict bedrock extraction are generally located within valleys such as the Gull River valley.

AGGREGATE QUALITY AND SUITABILITY

During field investigation, thirty-two samples were taken from existing pit faces and test pits. A quarry stockpile was also sampled. The samples were analyzed for grain size distribution (Figures 3a to 13b) and three aggregate quality tests were performed on selected samples. These tests include the absorption and Magnesium Sulphate Soundness tests, as well as petrographic analysis. The results of these tests are portrayed in Table 6. The three quality tests were performed in the laboratories of the Ontario Ministry of Transportation, Soils and Aggregates Section, Engineering Materials Office, Downsview. Grain size analyses were conducted in either the Ministry of Transportation Laboratories or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey.

In general, the aggregate in the report area is considered of sufficient quality for uses including 16 mm Crushed Stone Type B and granular base course. The results of the quality testing for the most part fall within Ontario Ministry of Transportation specification limits for these products. Higher specification uses of the aggregate, however, may be limited in some localities by the presence of friable and brittle gneissic particles within the gravel.

These brittle and friable particles are largely responsible for the high Los Angeles Abrasion and Impact losses given by local aggregates. Losses ranged between 24 and 65 percent for samples taken by the Ontario Ministry of Transportation in the area and most of the losses were greater than 35 percent.

The local aggregates perform well, however, in asphalt pavements in the field. Consequently, the Ministry of Transportation has modified their specifications to permit a loss of up to 50 percent in aggregate taken from the area, instead of the usual 35 percent loss (Rogers 1985). Similarly, the Ministry of Transportation has modified the maximum petrographic number allowed in Hot-Laid No. 4 aggregate to 180 from 160.

Although specifications have been modified, several samples still do not meet criteria for use in Hot-Laid No. 4 asphalt. Out of 39 sites sampled by the Ontario Ministry of Transportation and the Aggregate Assessment Office, samples from 16 of the pits had petrographic numbers or Magnesium Sulphate Soundness losses in excess of the modified specification limits. Most of these sites are located in the Dorset-Eagle Lake and Haliburton-Minden Map Areas. The highest quality aggregates in the report area may be available from Monmouth and Cardiff Townships. Samples taken from these townships contain lower amounts of friable and brittle gravel particles.

Although an aggregate may meet specifications, the local gravels are not accepted by the Ontario Ministry of Transportation for use in portland cement concrete which will be exposed to de-icing salts. There can be a bonding problem between the cement and gravel which results in spalling of the concrete. Consequently, calcareous aggregate imported from the south has been used to build bridge structures in the county. The aggregate in the area may also contain mica fragments (derived from the local bedrock) which do not bond well with cement mixes.

SUMMARY

The sand and gravel deposits in the report area are the product of glacial activity which occurred during the Late Wisconsinan Substage of the Pleistocene Epoch. A number of these deposits which contain significant resources of sand and gravel have been grouped together into 26 Primary Resource Areas. In addition, numerous deposits of secondary significance, which considerably add to the project area's resource base, have also been selected. Care should be taken to ensure the continued availability of as much of the resource areas as possible.

In general, the report area contains adequate resources of low specification aggregate. With the exceptions of Sherborne and Dudley geographic townships and Lutterworth, Glamorgan and Bicroft Townships, the area contains considerable resources of sandy aggregate. Deposits containing crushable gravel are, however, scarce in the area. The most significant potential sources of this material include outwash features located in Livingstone and McClintock geographic townships and Monmouth Township, as well as ice-contact deposits which are scattered throughout the project area.

The aggregate in the report area is generally suitable for most usual applications, however, use of the material in hot-laid asphalt may be restricted in places by the presence of brittle and friable rock types within the gravel. The lowest quantities of these objectionable rock types occur within gravel found in the easternmost townships. Local gravels are not accepted by the Ontario Ministry of Transportation for use in concrete which will be exposed to de-icing salts because there is a bonding problem between the aggregate and cement which results in concrete deterioration.

Precambrian aged bedrock of the Canadian Shield underlies the project area. Highly deformed, commonly interlayered quartzofeldspathic and mafic gneisses of indeterminate origin are the most widespread rock type. The bedrock in the area can exhibit wide variations in aggregate quality. Consequently, site specific testing is recommended prior to extraction.

Enquiries regarding the Aggregate Resources Inventory of Part of Haliburton County should be directed to the Aggregate Assessment Office, Engineering and Terrain Geology Section, Ontario Geological Survey, Room M1B-45, Macdonald Block, Queen's Park, 900 Bay Street, Toronto M7A 1W4, [Tel: (416) 965-1663], or to the Resident Geologist, Algonquin District, Ministry of Northern Development and Mines, Box 190, Dorset, P0A 1E0 [Tel: (705) 766-2494], or to the Resident Geologist, Southeastern District, Ministry of Northern Development and Mines, Box 70, 255 Metcalfe Street, Tweed, Ontario, K0K 3J0 [Tel: (613) 478-2330], or to the Bancroft District, Ministry of Natural Resources, P.O. Box 500, Highway 28, Bancroft, K0L 1C0 [Tel: (613) 332-3940]or to the Bracebridge District, Ministry of Natural Resources, Box 1138, Bracebridge, P0B 1C0 [Tel: (705) 645-8747], or to the Minden District, Ministry of Natural Resources, Minden, K0M 2K0, [Tel: (705) 286-1521].

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
DORSET-EAGLE LAKE MAP AREA			
Livingstone Geographic Township			
1	G-E	22 (9)	2 (2)
2	G-OW	230 (93)	7 (6)
	S-OW	160 (65)	5 (4)
3	G-OW	590 (239)	12 (11)
	S-IC	130 (53)	3 (3)
	S-OW	1450 (590)	29 (26)
4	S-OW	820 (330)	8 (7)
		3400 (1380)	66 (60)
McClintock Geographic Township			
1	G-IC	52 (21)	3 (3)
	S-IC	20 (8)	1 (1)
2	G-IC	36 (15)	1 (1)
	G-OW	760 (310)	23 (21)
	G-OW-IC	350 (142)	10 (9)
	S-IC	24 (10)	<1 (<1)
	S-OW	340 (138)	10 (9)
3	G-IC	30 (12)	<1 (<1)
	G-OW	340 (138)	7 (6)
	G-OW-IC	10 (4)	<1 (<1)
	S-OW	1700 (690)	34 (31)
4	S-OW	850 (345)	8 (7)
		4500 (1820)	97 (88)
Sherborne Geographic Township			
1	G-E	10 (4)	<1 (<1)
	G-IC	60 (24)	3 (3)
	G-K	5 (2)	<1 (<1)
	S-OW	430 (174)	22 (20)
2	G-IC	60 (24)	2 (2)
	G-OW	17 (7)	<1 (<1)
	S-K	6 (2)	<1 (<1)
	S-LP	30 (12)	1 (1)
	S-LP-OW	180 (73)	5 (4)
	S-OW	320 (130)	9 (8)

N.B. Minor variations in all tables are caused by rounding of data.

*Identified deposit areas within Algonquin, Oxtongue River - Ragged Falls and Silent Lake Provincial Parks, and Dividing Lake Provincial Nature Reserve are omitted on all tables.

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
3	G-OW	310 (125)	6 (5)
	G-IC	3 (1)	<1 (<1)
	S-LD	75 (30)	1 (1)
	S-LP	110 (45)	2 (2)
	S-OW	450 (182)	9 (8)
4	S-LP-OW	50 (20)	<1 (<1)
	S-OW	285 (115)	3 (3)
		2400 (970)	63 (57)
Stanhope Township			
1	G-E	42 (17)	4 (4)
	G-LD	25 (10)	1 (1)
	S-IC	24 (10)	2 (2)
	S-IC-LD	370 (150)	18 (16)
	S-ICT	70 (28)	4 (4)
	S-LD	110 (45)	6 (5)
	S-OW	205 (83)	10 (9)
2	G-IC	28 (11)	1 (1)
	S-EM	14 (6)	<1 (<1)
	S-IC	40 (16)	1 (1)
	S-ICT	30 (12)	1 (1)
	S-LD	70 (28)	3 (3)
	S-LP	740 (300)	22 (20)
	S-OW	250 (101)	8 (7)
	S-OW-LP	50 (20)	2 (2)
3	G-IC	310 (125)	6 (5)
	G-OW	70 (28)	1 (1)
	S-AL	40 (16)	1 (1)
	S-IC	30 (12)	<1 (<1)
	S-LD	45 (18)	1 (1)
	S-LP	890 (360)	18 (16)
	S-OW	295 (119)	6 (5)
	S-OW-LP	50 (20)	1 (1)
4	G-OW	45 (18)	<1 (<1)
	S-AL	40 (16)	<1 (<1)
	S-LP	125 (51)	1 (1)
	S-OW	410 (166)	4 (4)
		4400 (1780)	122 (111)

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
Guilford Geographic Township			
1	G-E	30 (12)	2 (2)
	G-IC	102 (41)	5 (4)
	S-IC	100 (40)	5 (4)
	S-ICT	185 (75)	9 (8)
	S-LD	710 (285)	37 (34)
	S-OW	400 (162)	20 (18)
2	G-IC	169 (68)	6 (5)
	S-E	7 (3)	<1 (<1)
	S-ICT	108 (44)	3 (3)
	S-LD	9 (4)	<1 (<1)
	S-LP	840 (340)	32 (29)
	S-LP-LD	106 (43)	4 (4)
3	G-OW	40 (16)	<1 (<1)
	S-AL	290 (117)	6 (5)
	S-IC	11 (4)	<1 (<1)
	S-ICT	102 (41)	2 (2)
	S-LP	275 (111)	6 (5)
	S-OW	270 (109)	5 (4)
4	S-OW	55 (22)	<1 (<1)
		3800 (1540)	141 (128)
TOTAL FOR DORSET-EAGLE LAKE MAP AREA:			
		18,500 (7500)	490 (445)
HALIBURTON-MINDEN MAP AREA			
Minden Geographic Township			
1	G-E	40 (16)	3 (3)
	G-IC	165 (67)	10 (9)
	G-SF	15 (6)	1 (1)
	S-IC	50 (20)	3 (3)
	S-LD	210 (85)	13 (12)
	S-SF	125 (51)	7 (6)
	S-OW-LD	85 (34)	3 (3)
2	G-E	35 (14)	1 (1)
	G-IC	330 (134)	11 (10)
	S-IC	165 (67)	5 (4)
	S-IC-LD	90 (36)	3 (3)
	S-LD	600 (243)	22 (20)
	S-OW	540 (219)	16 (15)

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
3	G-IC	205 (83)	4 (4)
	G-OW	160 (65)	3 (3)
	S-AL	60 (24)	1 (1)
	S-IC	105 (42)	2 (2)
	S-IC-LD	30 (12)	<1 (<1)
	S-LD	210 (85)	4 (4)
	S-LD-LP	60 (24)	1 (1)
	S-LP	210 (85)	4 (4)
	S-OW	295 (119)	6 (5)
	S-OW-LD	35 (14)	<1 (<1)
	S-OW-LP	140 (57)	3 (3)
4	G-IC	145 (59)	1 (1)
	S-LD-LP	30 (12)	<1 (<1)
	S-LP	55 (22)	<1 (<1)
	S-OW	145 (59)	1 (1)
	S-OW-LP	40 (16)	<1 (<1)
		4400 (1780)	129 (117)
Dysart Geographic Township			
1	G-IC	46 (19)	2 (2)
	S-IC	150 (61)	8 (7)
2	G-IC	56 (23)	2 (2)
	S-IC	126 (51)	5 (4)
	S-LD	285 (115)	10 (11)
3	G-OW	53 (21)	1 (1)
	S-IC	197 (80)	4 (4)
	S-LD	720 (290)	14 (13)
	S-LP	570 (231)	11 (10)
	S-OW	1740 (700)	35 (32)
4	S-IC	33 (13)	<1 (<1)
	S-OW	82 (33)	<1 (<1)
		4050 (1640)	92 (84)
Lutterworth Township			
1	G-SF	24 (10)	2 (2)
	S-SF	24 (10)	2 (2)
2	S-LD	420 (170)	16 (15)
	S-OW	5 (2)	<1 (<1)
	S-SF	55 (22)	2 (2)

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
3	S-LD	28 (11)	<1 (<1)
	S-LP	300 (121)	6 (5)
	S-OW	100 (40)	2 (2)
	S-OW-LP	24 (10)	<1 (<1)
4	S-AL	11 (4)	<1 (<1)
	S-LP	50 (20)	<1 (<1)
	S-OW	100 (40)	1 (1)
		1140 (460)	31 (28)
Snowdon Township			
1	G-E	93 (38)	5 (4)
	G-IC	80 (32)	6 (5)
	S-OW	85 (34)	6 (5)
2	G-E	31 (13)	1 (1)
	G-IC	50 (20)	2 (2)
	S-IC	13 (5)	<1 (<1)
	S-OW	750 (305)	27 (24)
3	G-IC	410 (166)	8 (7)
	G-OW	285 (115)	6 (5)
	S-IC	50 (20)	1 (1)
	S-LP	100 (40)	2 (2)
	S-OW	3800 (1540)	76 (69)
	S-OW-IC	65 (26)	1 (1)
4	S-AL	100 (40)	1 (1)
	S-LP	35 (14)	<1 (<1)
	S-OW	160 (65)	1 (1)
		6100 (2470)	143 (130)
Glamorgan Township			
2	S-IC	23 (9)	<1 (<1)
	S-OW	600 (243)	22 (20)
3	S-IC	24 (10)	<1 (<1)
	S-OW	1130 (455)	23 (21)
4	S-IC	21 (8)	<1 (<1)
	S-OW	25 (10)	<1 (<1)
		1820 (740)	45 (41)
TOTAL FOR HALIBURTON-MINDEN MAP AREA:		17 500 (7100)	440 (400)

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
TORY HILL-CARDIFF MAP AREA			
Dudley Geographic Township			
2	S-IC	8 (3)	<1 (<1)
	S-OW	650 (265)	18 (16)
3	G-OW	47 (19)	<1 (<1)
	S-IC	84 (34)	1 (1)
	S-OW	152 (62)	3 (3)
4	G-OW	158 (64)	2 (2)
	S-IC	31 (13)	<1 (<1)
	S-OW	102 (41)	1 (1)
		1230 (500)	25 (23)
Monmouth Township			
1	G-E	17 (7)	1 (1)
2	G-OW	105 (42)	4 (4)
	S-IC	67 (27)	2 (2)
	S-OW	1210 (490)	45 (41)
3	S-IC	76 (31)	2 (2)
	S-OW	2070 (840)	41 (37)
4	S-OW	176 (71)	2 (2)
		3700 (1500)	97 (88)
Cardiff Township			
1	G-E	24 (10)	2 (2)
	G-IC	166 (67)	10 (9)
	G-ICT	71 (29)	7 (6)
	S-E	5 (2)	<1 (<1)
	S-IC	134 (54)	8 (7)
2	G-IC	48 (19)	1 (1)
	G-OW	9 (4)	<1 (<1)
	S-IC	435 (176)	16 (14)
	S-OW	315 (127)	12 (11)
3	G-IC	13 (5)	<1 (<1)
	G-OW	290 (117)	6 (5)
	S-IC	244 (99)	5 (4)
	S-OW	1720 (700)	34 (31)
4	G-OW	27 (11)	<1 (<1)
	S-IC	3 (1)	<1 (<1)
	S-OW	126 (51)	1 (1)
		3650 (1480)	102 (92)

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, PART OF HALIBURTON COUNTY.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
Bicroft Township			
2	S-IC	25 (10)	<1 (<1)
3	S-OW	770 (310)	15 (14)
		795 (320)	15 (14)
TOTAL FOR TORY HILL-CARDIFF MAP AREA:			
		9400 (3800)	239 (217)
TOTAL FOR STUDY AREA:			
		45,500 (18 400)	1170 (1060)

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
DORSET-EAGLE LAKE MAP AREA						
Livingstone Geographic Township						
1	K15-18	4	4	10 (3)	-	mainly sand
2	-	15,16	13	10-15 (3-5)	-	slumped faces, water on pit floor
3	-	17	12	-	-	water on pit floor, near depletion
4	-	9	11	20 (6)	15-20	
5	-	20,21	10	10 (3)	50-70	abundant boulders
6	-	17,18	9	5 (1.5)	45	
7	-	16,17	7	3-5 (1-1.5)	-	medium to coarse sand
8	-	13	10	3-6 (1-1.8)	45-65	medium to coarse gravel
9	-	10	8	10 (3)	50-70	coarse gravel with abundant oversize, overgrown
10	-	9,10	6	10-15 (3-5)	50-70	coarse gravel with abundant oversize, overgrown
11	-	11	6	10 (3)	40-55	
12	-	7,8	6	10 (3)	65-80	coarse gravel, abundant boulders
13	-	9,10	6	10 (3)	45-55	
14	-	3	5	10 (3)	-	till
15	-	8	4	5 (1.5)	45-55	mainly fine gravel
16	-	5	3	<5 (<1.5)	-	depleted to bedrock
17	-	9	2	5-10 (1.5-3)	50-70	overgrown

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
McClintock Geographic Township						
18	-	31,32	13	5-15 (1.5-5)	variable	material ranges from sand to coarse gravel
19	K15-7	20	14	-	-	depleted to bedrock
20	K15-7	18	13,14	5-10 (1.5-3)	60-70	coarse gravel, near depletion
21	K15-7	18	14	5 (1.5)	variable	
22	K15-11	9	13,14	5-10 (1.5-3)	variable	slumped, overgrown
23	K15-26	10	12	3-10 (1-3)	variable	slumped faces, overgrown
24	K15-37	10	12	10-15 (3-5)	50-80	graded slopes, water on pit floor
25	K15-36	5,6	11	5-10 (1.5-3)	50-70	medium to coarse gravel
26	-	5,6	10,11	15 (5)	25	3 feet (1 m) of fine to medium gravel over coarse sand with minor fine gravel
27	-	3	10	5-12 (1.5-4)	35-40	fine to medium gravel
28	-	31	5	10 (3)	-	till
29	-	29	6	<5 (<1.5)	-	mainly sand
30	-	21	6	5-8 (1.5-2)	60-70	
31	-	18	5	20 (6)	-	mainly sand
32	-	18	5	8 (2)	-	gravelly sand
33	-	24	3	25-30 (8-9)	20-25	gravelly fine to coarse sand
34	-	15	3	10-20 (3-6)	50-70	coarse gravel

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
35	-	14	2	10-25 (3-8)	20-30	occasional coarse gravel pocket
36	-	14	2	5-15 (1.5-5)	<20	silty fine sand sections
37	-	12	3	8 (2)	45-65	bedrock on pit floor
38	-	11,12	2	10-15 (3-5)	<5	largely medium sand
39	-	10	2	5 (1.5)	50-55	mainly fine gravel
40	-	6	1	6 (1.8)	20	sand with some fine gravel
Sherborne Geographic Township						
41	-	32	12	10 (3)	-	slumped faces
42	-	24,25	12	6-20 (1.8-6)	5-30	predominantly sand with fine gravel, gravel concentrated in upper levels of pit
43	-	20	11	10-20 (3-6)	<10	medium to coarse sand with occassional gravel pockets
44	-	14	11	8-20 (2-6)	0-40	mainly medium sand, southern faces expose 8 feet (2 m) of sandy gravel
45	-	12	10	6-10 (1.8-3)	-	medium to coarse sand with fine gravel, water on pit floor
46	-	14	10	-	-	rehabilitated
47	-	12	9	5 (1.5)	-	silty fine sand, overgrown, water on pit floor

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
48	-	26	A	10-25 (3-8)	0-50	variable material ranging from coarse gravel to silty fine sand, bedrock exposed in places
49	-	19	6	10 (3)	25	sand with fine gravel
50	-	18,19	6	5-10 (1.5-3)	-	gravelly sand, slumped
51	-	13	A	5 (1.5)	25-30	medium to coarse sand with fine gravel
52	-	2	4	5-15 (1.5-5)	40	
53	-	3	3	-	-	rehabilitated
Stanhope Township						
54	H2-30	17	10	10-15 (3-5)	-	slumped medium to coarse gravel
55	H2-41	17,18	9	6-10 (1.8-3)	10-15	gravelly sand
56	H2-40	18	8	20 (6)	-	8 feet (2 m) fine to coarse gravel over 12 feet (4 m) of sand with minor fine gravel
57	-	18	8	5-15 (1.5-5)	10-25	gravel concentrated in upper 5 feet (1.5 m)
58	-	16	8	5-8 (1.5-2)	10	2 feet (0.6 m) of sandy fine gravel over medium sand
59	-	8	6	10-15 (3-5)	5	2 feet (0.6 m) of fine gravel over sand
60	-	10	A	5 (1.5)	-	depleted to bedrock
61	-	3	1,2	10 (3)	-	till

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Trans-portation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
62	-	6	1	5-8 (1.5-2)	0	medium sand, overgrown
63	H2-45	13	5	10-20 (3-6)	-	mainly sand, gravel concentrated in upper 2 feet (0.6 m), water on pit floor, bedrock exposed on floor
64	H2-44	13	5	10-15 (3-5)	5	fine to coarse sand with layers of fine gravel
65	H2-1,2	14	4	10-35 (3-11)	-	mainly sand, occasional gravel pocket
66	-	15	4	10 (3)	-	mainly medium to coarse sand
67	H2-3	15	1	8-10 (2-3)	<5	largely medium sand with minor amounts of fine gravel
68	-	18	1	8 (2)	-	bedrock exposed in pit face, near depletion
69	-	19	1	5 (1.5)	-	sandy fine to coarse gravel
70	-	22,23	3	8 (2)	-	sand, overgrown
71	-	20,21	4	5-10 (1.5-3)	-	largely medium to coarse sand
72	-	19	4	8 (2)	10-20	medium to coarse sand with some fine gravel in upper layers
73	-	20	6	6 (1.8)	-	mainly sand
74	H2-82	27	7	8-16 (2-5)	10-20	pockets of fine to coarse gravel near surface

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
75	-	29	7	10-25 (3-8)	-	mainly sand with pockets of gravel, slumped faces
76	-	32	6	10-25 (3-8)	0-60	fresh faces, variable material
77	H2-72	30	4	8-15 (2-5)	-	near depletion, material variable from sand to till
78	-	31,32	4	8-18 (2-5)	10	occasional boulders
Guilford Geographic Township						
79	H2-68	5	2	6-7 (1.8-2)	20-30	faces slumped, overgrown, water on pit floor
80	H2-43	4	4	20 (6)	-	sand, partly rehabilitated
81	H2-43	3	4	10-15 (3-5)	-	sand
82	-	6	5	10 (3)	-	sand
83	-	5	6	<5 (<1.5)	-	mainly sand
84	-	3	7	15-30 (5-9)	<5	
85	-	6	7	10-12 (3-4)	15-20	
86	-	12	6	10-12 (3-4)	-	sand
87	-	12	7	5-10 (1.5-3)	10-20	silty sections
88	H2-80	12	6	30-40 (9-12)	-	sand, worked in several levels
89	H2-80	12	6	20 (6)	20-30	worked in several levels
90	-	13	6	6-12 (1.8-4)	10-20	
91	-	14	7	6 (1.8)	-	mainly sand

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
92	H2-69	13	6	20 (6)	variable	worked in several levels
93	H2-81	14	6	6-10 (1.8-3)	20-40	
94	H2-57	15	6	15-25 (5-8)	20-30 variable	recent extraction, water on pit floor
95	H2-57	15	6	10-15 (3-5)	-	depleted to bedrock
96	-	16	7	12-15 (4-5)	40-50	faces slumped, overgrown
97	-	19	7	5-20 (1.5-6)	60-80	abundant oversize
98	-	20	7	15 (5)	70-80	
99	-	21	7	5-6 (1.5-1.8)	-	overgrown
100	-	11	4	20 (6)	-	sand, inactive
101	H2-77	12	4	20-30 (6-9)	-	faces have been graded
102	-	13	4	20-25 (6-8)	-	mainly sand, overgrown
103	-	14	4	5-30 (1.5-9)	5-10	
104	-	20	3	6-8 (1.8-2)	-	mainly sand
105	-	22	4	12-15 (4-5)	10-20	partially overgrown
106	-	23	4	10-12 (3-4)	-	mainly sand
107	H2-21	22	4	10-30 (3-9)	10-15 variable	worked in several faces
108	-	23	4	10-20 (3-6)	30-40	
109	-	29	1	6-8 (1.8-2)	20-40	
110	-	34	3	6-8 (1.8-2)	-	overgrown
111	-	31	4	10-12 (3-4)	-	till, overgrown
112	-	31	5	5-10 (1.5-3)	-	till

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
113	-	35	9	4-6 (1.2-1.8)	30-45	water on pit floor
114	-	31	10	8-10 (2-3)	30-40	overgrown, near depletion
115	-	18	13	10-20 (3-6)	-	till
HALIBURTON-MINDEN MAP AREA						
Minden Geographic Township						
116	-	6	13	30-35 (9-11)	-	coarse gravel, abundant oversize
117	-	4	13	20-30 (6-9)	0	fine to medium sand
118	-	1	11,12	<5 (<1.5)	0	sand, overgrown
119	-	1	11	5-10 (1.5-3)	0	medium sand
120	-	2	11	5-15 (1.5-5)	30-45	
121	-	2	11	10 (3)	65-75	pit developed in hummock
122	-	23	A	10 (3)	-	till
123	H2-74	7	10	10-17 (3-5)	variable	material varies from sand to coarse gravel
124	-	7	9,10	10-15 (3-5)	0	sand
125	-	4	7	25 (8)	-	till
126	-	14	A	10-20 (3-6)	50-70	up to 6 feet (2 m) of silt and clay overlies aggregate in western faces, abundant oversize
127	-	11	A	10-15 (3-5)	10-50	limonite coated gravel in pockets

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
128	-	2,3	3	30-50 (9-15)	-	largely sand with minor amounts of fine gravel, overlain by 15 feet (5 m) of silt and clay
129	M20-14	3	2	15 (5)	20-40	near depletion
130	M20-16	6	5	5-10 (1.5-3)	0	medium sand with silty fine sand layers and silt seams
131	M20-59	7	4	-	-	rehabilitated
132	M20-59	7	3	-	-	rehabilitated
133	-	8	4	10-15 (3-5)	-	faces graded
134	-	11	5	8 (2)	-	mainly fine to coarse sand, till in pockets
135	-	11	5	25 (8)	15	mainly sand with minor amounts of fine gravel, one 2-foot (0.6 m) thick coarse gravel layer
136	-	12	5	5-15 (1.5-5)	10-20	overgrown
137	-	11	5	<5 (<1.5)	-	slumped gravel faces, near depletion
138	-	11	6,7	10 (3)	-	till
139	-	14	11	10-20 (3-6)	20-45	partly rehabilitated, gravel concentrated near surface
140	-	15	11	<5 (<1.5)	40-50	partly overgrown
141	H2-11	16	11	5 (1.5)	45-60	water on pit floor

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
142	H2-58	14	13	5-10 (1.5-3)	5	2 feet (0.6 m) gravelly medium to coarse sand over fine to medium sand
143	-	15	13	10 (3)	variable	pit being developed during field investigation, material ranges from coarse gravel to silt and clay
144	H2-29	18	13	5-10 (1.5-3)	-	slumped gravel faces, partly rehabilitated
145	-	18	13	-	-	depleted to bedrock
146	-	28	13	<5 (<1.5)	-	coarse gravel, overgrown
147	-	29	11	5-10 (1.5-3)	0	medium to coarse sand
148	-	28	10	5-8 (1.5-2)	0	mainly medium sand, till underlies sand in southwest corner of pit
149	-	30	10	8-10 (2-3)	0	fine to medium sand with silt seams
150	-	25	9	5-10 (1.5-3)	-	till
151	-	26	7	10 (3)	-	till
152	-	26	6	10-20 (3-6)	-	till
153	-	18	7	15 (5)	10-15	5 feet (1.5 m) of gravelly coarse sand over fine to medium sand
154	-	17,18	5	<5 (<1.5)	20	fine to medium sand with thin fine gravel layers

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
155	-	19	2	4-15 (1.2-5)	-	mainly sand, occasional silt seams
156	M20-18	19,20	2	5-15 (1.5-5)	variable	fine sand to coarse gravel
157	-	27	2	5 (1.5)	40-60	overgrown
158	-	26	2	10-15 (3-5)	-	coarse gravel at surface, pit in process of development
159	M20-5	27	2	10-25 (3-8)	60-70	
160	-	28	4	40 (12)	35-70	active extraction
161	M20-98	28	4	25-30 (8-9)	variable	sand to coarse gravel
Dysart Geographic Township						
162	-	4	7	6-10 (1.8-3)	5-10	gravel in pockets
163	H2-27	5	7	15-20 (5-6)	-	sand, water on pit floor, recent extraction
164	-	5	8	10 (3)	-	mainly sand, abundant boulders
165	-	7	8	5-20 (1.5-6)	variable	partially overgrown, some faces slumped
166	-	4	1	20 (6)	-	sand, rehabilitated
167	-	5	1	20 (6)	-	mainly sand, rehabilitated
168	-	9	2	8-12 (2-4)	-	mainly sand, depleted to bedrock in face and floor
169	H2-18	9	5	10-60 (3-18)	-	faces slumped and overgrown

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
170	-	8	5,6	8-10 (2-3)	-	mainly sand, water on pit floor
171	-	8	5,6	5-15 (1.5-5)	-	sand, water on pit floor
172	-	8	6	5 (1.5)	-	sand, overgrown
173	-	8	6	10-25 (3-8)	-	sand, underlain by weathered bedrock
174	H2-16	11	6	-	-	sand, faces have been graded
175	H2-23	10	7	5-10 (1.5-3)	-	silty sand, water in pit floor, faces slumped, partially overgrown
176	-	12	7	8-15 (2-5)	-	sand, depleted to bedrock, water in pit floor
177	H2-79	15	10	3-12 (1-4)	-	sand, silty sections
178	-	16	10	3-10 (1-3)	-	sand
179	-	17	9	<5 (<1.5)	-	sand
180	-	19	10	8-15 (2-5)	-	till
181	-	25	8	<5 (<1.5)	-	gravel, water on pit floor, overgrown
182	-	25	8	<5 (<1.5)	-	sand, abundant boulders, water on pit floor
183	-	19	3	6 (1.8)	20-30	
184	-	20	3	10 (3)	-	mainly sand
185	-	24	3	5-8 (1.5-2)	20-30	water on pit floor
186	-	25	4	5-10 (1.5-3)	-	mainly sand, recent extraction

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
187	-	29	4	8-12 (2-4)	30-40	depleted to bedrock
188	-	29	4	8-12 (2-4)	-	mainly sand, depleted to bedrock in face and floor
189	W22-23	28,29	5	6-10 (1.8-3)	-	sand, water on pit floor
190	-	29	5	20 (6)	-	sand, overgrown
191	-	30	4	6-12 (1.8-4)	-	mainly sand, faces slumped
192	W22-27	31	5	10-15 (3-5)	-	mainly sand, crushable gravel located north of swamp
193	W22-1-2	32	5	8-30 (2-9)	40-60	oversize material present
194	W22-1-1	32	5	10-15 (3-5)	-	mainly sand
195	-	33	5	5-8 (1.5-2)	40-60	sawmill in part of pit
Lutterworth Township						
196	M20-36	29	3	10-20 (3-6)	0-50	gravel in pockets
197	M20-10	25	6	20-35 (6-11)	10	gravel in pockets
198	M20-9	24	6	20-30 (6-9)	-	near depletion, bedrock exposed in face
199	M20-43	23	7	5-15 (1.5-5)	-	mainly sand, occasional pocket of gravel
200	-	23	7	<5 (<1.5)	0	sand, overgrown
201	-	16	12	8-10 (2-3)	0	fine to medium sand, water on pit floor

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
202	-	9	13	5-10 (1.5-3)	variable	fine sand and till
203	-	7	14	10 (3)	40-70	coarse gravel
204	M20-73	8	13	35-50 (11-15)	10-70	coarse gravel pockets up to 20 feet (6 m) thick
205	M20-42	5	13	10-20 (3-6)	-	mainly sand
206	-	5	13	-	-	sand, overgrown
207	-	5	13	10-15 (3-5)	-	3 feet (1 m) of gravel overlying medium to coarse sand
208	M20-3a	5	12	15-20 (5-6)	0	fine to medium sand, bedrock exposed in places on pit floor
209	-	4	13	5-10 (1.5-3)	-	silty fine sand to coarse sand, one gravel pocket
210	-	3	13	10-15 (3-5)	20	bedrock exposed in pit floor
211	-	3	12	15-20 (5-6)	-	medium to coarse sand, slumped
212	-	3	12	10-15 (3-5)	0	fine sand
213	-	2	13	10-20 (3-6)	variable	sand to coarse gravel, bedrock exposed in pit face, near depletion
214	-	2	14	5-8 (1.5-2)	-	mainly sand
215	-	8	5	5-13 (1.5-4)	-	mainly sand, pit worked in two levels

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
216	-	7	5	<5 (<1.5)	-	sandy gravel overlying bedrock
217	-	6	A	10-20 (3-6)	0	fine to medium sand
218	-	1	A,1	8-20 (2-6)	0	fine to medium sand
Snowdon Township						
219	-	6	A	5 (1.5)	-	sand, bedrock exposed in pit floor
220	M20-4	6	A	15 (5)	10	active extraction
221	-	5	A	5 (1.5)	-	sand, overgrown
222	M20-91	33,34	A	<5 (<1.5)	-	depleted, bedrock exposed in pit floor
223	-	5	14	8 (2)	-	till
224	M20-17	5	13	3-6 (1-2)	35	bedrock exposed on pit floor
225	M20-69	8,9	13	5-20 (1.5-6)	45-65	coarse gravel with abundant oversize material
226	M20-78	12	14	10-20 (3-6)	-	overgrown
227	-	14	14	20-25 (6-8)	45-60	pit developed in small ice-contact hummock
228	M20-33	20	14	10-45 (3-14)	60-70	
229	-	25	14	5-8 (1.5-2)	variable	sand to coarse gravel
230	-	26	13	10 (3)	-	mainly sand, overgrown

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
231	-	20	13	8-20 (2-6)	40-45	variable from sand to coarse gravel, pit developed in ice-contact hummock
232	-	21	13	10 (3)	10-35	variable from sand to medium gravel
233	-	20	13	10-40 (3-12)	40-75	variable material
234	M20-55	16	11	10 (3)	-	overgrown
235	M20-21	15,16	11	5-10 (1.5-3)	-	sand, slumped faces
236	M20-51	15	10	10 (3)	<10	medium to coarse sand with minor amounts of fine gravel concentrated in the upper levels
237	M20-52	16	10	10 (3)	<5	mainly fine to coarse sand with occasional silt seams
238	-	18	9	5-10 (1.5-3)	50-70	coarse gravel with oversize material
239	-	14	9	5 (1.5)	-	sandy gravel, overgrown
240	-	14,15	8	5-7 (1.5-2)	40	sand to medium gravel
241	-	14	8	30-40 (9-12)	-	mainly medium sand, pit developed into terrace slope
242	-	18	8	5-10 (1.5-3)	-	medium to coarse gravel
243	M20-30	14	7	25 (8)	55	largely coarse gravel with sand pockets

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
244	M20-30	13	7	30 (9)	-	mainly sand, slumped and overgrown faces
245	M20-67	7	1,2	10-30 (3-9)	5-25	fine sand to coarse gravel, 1- to 5-foot (0.3-1.5 m) silt seams
246	M20-80	12	2	5 (1.5)	-	mainly sand
247	-	14,15	2	15-20 (5-6)	<5	sand
248	M20-31	15	3	5-10 (1.5-3)	-	graded faces, gravel in pockets
249	-	16	2	10-15 (3-5)	0	fine to coarse sand
250	M20-79	19	2	10 (3)	0	sand
251	M20-82	19	2	15-20 (5-6)	0	sand
Glamorgan Township						
252	-	1	7	10-15 (3-5)	-	sand, depleted to bedrock
253	M20-90	1	6	9-12 (3-4)	-	sand, silty sections
254	-	1	5	15-20 (5-6)	5	
255	G3-74	3	6	10-12 (3-4)	5	
256	G3-36	19	6	5-10 (1.5-3)	-	sand, faces slumped, partly overgrown
257	-	1	15	-	-	sand
258	-	19	11	6-10 (1.8-3)	-	depleted to bedrock in face and floor
259	-	23	11	3-5 (1-1.5)	20-40	
260	-	34	13	10-15 (3-5)	-	depleted
261	-	28	10	-	-	till, depleted to bedrock in floor

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
262	-	25	5	10-15 (3-5)	-	mainly sand, depleted to bedrock in one face, gravel in pocket, water in pit floor
263	-	26	5	-	-	depleted to bedrock
264	-	26	5	20 (6)	-	sand, up against bedrock
265	-	24	4	20 (6)	-	till, overgrown
266	G3-68	34	6	5 (1.5)	-	sand, overgrown
267	G-81	30	5	8-12 (2-4)	-	mainly sand, part of pit used as dump, water on pit floor
268	-	31	5	4-5 (1.2-1.5)	-	mainly sand
269	-	30	3	8-12 (2-4)	-	sand, depleted to bedrock, faces overgrown
270	-	34	3	10-12 (3-4)	-	gravelly sand, active extraction
TORY HILL-CARDIFF MAP AREA						
Dudley Geographic Township						
271	-	13	13	-	-	no access
272	-	13	13	-	-	no access
273	-	10	12	8-10 (2-3)	-	mainly sand
274	-	10	12	6-10 (1.8-3)	-	mainly sand
275	-	9	11	10-15 (3-5)	-	sand, overgrown, silty layer
276	-	3	8	20 (6)	-	till
277	-	10	7	8-10 (2-3)	-	mainly sand, water on pit floor

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
278	-	27	7	4-7 (1.2-2)	-	mainly sand, water on pit floor
279	-	35	7	3-6 (1-1.8)	-	mainly sand, overgrown, water on pit floor
280	-	34	4	10-15 (3-5)	20	
281	-	14	2	3-5 (1-1.5)	40-60	water on pit floor
Monmouth Township						
282	-	19	15	10 (3)	5-10	
283	-	19	14	5-15 (1.5-5)	-	mainly sand, depleted to bedrock in floor, water in pit floor
284	-	3	7	5-10 (1.5-3)	-	till
285	-	4	7	4-6 (1.2-1.8)	-	mainly sand
286	-	23	1	6-10 (1.8-3)	-	mainly sand, faces slumped, partially overgrown
287	-	25	4	3-10 (1-3)	-	till
288	G3-34	16	6	6-15 (1.8-5)	40-55	water on pit floor
289	G3-83	19	6	4-12 (1.2-4)	40-60	active extraction
290	G3-83	19	6	5-8 (1.5-2)	15-25	
291	-	21	6	5-7 (1.5-2)	-	sand, faces slumped
292	-	23	6	4-5 (1.2-1.5)	-	sand, faces slumped
293	G3-41	23	6	5-6 (1.5-1.8)	-	gravelly sand, faces slumped, overgrown
294	-	24	7	3-5 (1-1.5)	-	gravelly sand

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
295	G3-27	28	8	5-6 (1.5-1.8)	20-30	
296	G3-75	27	8	6-8 (1.8-2)	30-50	
297	-	33	10	5-12 (1.5-4)	10	
298	G3-31	33	10	4-12 (1.2-4)	5-40 variable	worked in several faces
299	G3-24	28	10	5-20 (1.5-6)	-	mainly sand, faces slumped
300	-	28	11	10 (3)	30-40	overgrown
301	G3-24	30	12	6-15 (1.8-5)	15-35	gravel in pockets
302	-	34	12	3-8 (1-2)	-	mainly sand, faces slumped, overgrown
303	-	35	12	5-10 (1.5-3)	-	mainly sand, faces slumped, overgrown
304	-	31	13	10-12 (3-4)	-	mainly sand, faces slumped, overgrown, water on pit floor
305	W22-44	33	13	3-10 (1-3)	35-45	pockets of gravel
306	W22-44	33	13	3-8 (1-2)	40-50	pockets of gravel
307	-	26	14	5-10 (1.5-3)	<5	
308	-	35	15	3-10 (1-3)	-	sand
309	-	31	16	5-15 (1.5-5)	-	sand, bedrock exposed in pit floor, faces slumped, overgrown
310	-	33	17	4-6 (1.2-1.8)	-	till
Cardiff Township						
311	W22-40	1	22	5-10 (1.5-3)	-	sand, faces slumped

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
312	W22-6	1	22	12-15 (4-5)	40-50	crushable material in pockets
313	W22-36	2	22	15-30 (5-9)	30-40 variable	
314	-	6	22	8-12 (2-4)	-	sand, boulders
315	-	13	22	-	-	overgrown
316	W22-38	14	22	15-25 (5-8)	30-50	
317	-	14	22	30 (9)	-	mainly sand, gravel pocket
318	-	19	21	5-10 (1.5-3)	-	mainly sand, bedrock exposed in pit face
319	W22-14	24	22	4-12 (1.2-4)	30-40	water on pit floor
320	-	23	21	20 (6)	-	overgrown
321	-	27	20	10-20 (3-6)	-	sand, bedrock exposed in one face
322	W22-11	26	20	20-30 (6-9)	<5	
323	W22-11	25	20	10-15 (3-5)	20	partially overgrown
324	W22-11	25	20	40 (12)	50-60	abundant oversize material
325	W22-11	25	20	10-40 (3-12)	40-60	abundant oversize material, clay coating on clasts in one area
326	-	25	19	6-20 (1.8-6)		sand, faces slumped, overgrown
327	W22-10	25	19	6-25 (1.8-8)	20-40 variable	abundant oversize material
328	-	25,26	18	5-6 (1.5-1.8)	35-45	
329	W22-2	25	18	5-8 (1.5-2)	40-50	faces slumped

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
330	-	31	17	20 (6)	-	gravelly sand
331	W22-25	A	19	-	-	no access
332	-	2	9	6-7 (1.8-2)	-	mainly sand, bedrock exposed in pit faces and floor
333	-	6	7	5-6 (1.5-1.8)	10-20	bedrock exposed in pit face, water on pit floor
334	-	5	7	8-15 (2-5)	-	mainly sand, bedrock exposed on pit floor
335	-	5	7	6-15 (1.8-5)	-	mainly sand, bedrock exposed in pit face
336	-	4	7	5-15 (1.5-5)	-	mainly sand
337	-	5	7	10-20 (3-6)	-	overgrown
338	-	5	6	5-10 (1.5-3)	10-20	overgrown
339	-	7	6	6-8 (1.8-2)	-	sand, depleted to bedrock in pit floor
340	-	7	6	6-8 (1.8-2)	-	sand, water on pit floor
341	-	6	5	6-7 (1.8-2)	-	sand, water on pit floor
342	-	2	4	3-8 (1-2)	-	sand, bedrock in pit floor, water on pit floor
343	-	1	4	5-6 (1.5-1.8)	-	till, bedrock exposed, overgrown
344	-	1	4	5-6 (1.5-1.8)	-	till, bedrock exposed
345	-	12	4	5-10 (1.5-3)	<5	

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Trans-portation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
346	G3-17	12	4	5-15 (1.5-5)	-	mainly sand, bedrock exposed in pit floor
347	G3-52	13	5	5-6 (1.5-1.8)	-	mainly sand, faces slumped, beginning to be overgrown
348	G3-15	15	6	10-20 (3-6)	20-35	
349	-	15	7	-	-	overgrown
350	-	19	8	20-30 (6-9)	-	mainly mainly sand, faces slumped
351	G3-51	18	6	20 (6)	-	sand
352	-	22	4	8-10 (2-3)	5-10	
353	-	26	3	12 (4)	-	mainly sand, overgrown, water on pit floor
354	-	28	4	8-10 (2-3)	-	sand
355	G3-5	21	6	10-12 (3-4)	30-50	
356	G3-6	23	6	12-15 (4-5)	-	mainly sand, faces slumped, overgrown
357	G3-53	25	6	4-5 (1.2-1.5)	-	sand
358	-	25	9	3-8 (1-2)	20-30	pit faces slumped

TABLE 2. SAND AND GRAVEL PITS, PART OF HALIBURTON COUNTY.

1 No.	2 Ministry of Transportation No.	3 Lot	4 Con.	5 Face Height Feet (Metres)	6 % Gravel	7 Remarks
Bicroft Township						
359	-	13	10	5-8 (1.5-2)	-	mainly sand
360	-	19	11	4-8 (1.2-2)	-	till
361	-	28	11	6-8 (1.8-2)	15-25	presently a dump site
362	W22-16	29	11	10-12 (3-4)	15-25	faces slumped, overgrown
363	-	30	11	5 (1.5)	-	sand, water on pit floor, boulders present
364	-	29	11	5-20 (1.5-6)	-	till
365	-	28	10	5 (1.5)	-	sand, water on pit floor, now used as a dump
366	-	28	10	5-20 (1.5-6)	-	sand, bedrock exposed in pit face

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area	3 Cultural Setbacks	4 Extracted Area	5 Available Area	6 Estimated Deposit Thickness	7 Available Aggregate
	Acres (Hectares)	Acres (Hectares)	Acres (Hectares)	Acres (Hectares)	Feet (Metres)	Millions of Tons (Tonnes)
DORSET-EAGLE LAKE MAP AREA						
Livingstone Geographic Township						
1a	440 (178)	135 (55)	5 (2)	300 (121)	8 (2)	6 (5)
1b	210 (85)	75 (30)	5 (2)	130 (53)	12 (4)	4 (4)
	650 (265)	210 (85)	10 (4)	430 (174)		10 (9)
2a	17 (7)	0 (0)	0 (0)	17 (7)	30 (9)	1 (1)
	670 (270)	210 (85)	10 (4)	450 (182)		11 (10)
McClintock Geographic Township						
2b	25 (10)	0 (0)	0 (0)	25 (10)	25 (8)	2 (2)
3a	680 (275)	215 (87)	15 (6)	450 (182)	12 (4)	14 (13)
3b	350 (142)	50 (20)	0 (0)	300 (121)	12 (4)	9 (8)
	1140 (460)	265 (107)	15 (6)	860 (350)		23 (21)
4a	20 (8)	0 (0)	1 (<1)	19 (8)	20 (6)	<1 (<1)
4b	27 (11)	2 (1)	4 (2)	21 (8)	20 (6)	1 (1)
4c	20 (8)	7 (3)	2 (1)	11 (4)	10 (3)	<1 (<1)
	67 (27)	9 (4)	7 (3)	51 (21)		1 (1)
	1230 (500)	275 (111)	22 (9)	940 (380)		26 (24)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
Sherborne Geographic Township						
5a	70 (28)	50 (20)	0 (0)	20 (8)	20 (6)	1 (1)
5b	390 (158)	95 (38)	5 (2)	290 (117)	20 (6)	14 (13)
	460 (186)	145 (59)	5 (2)	310 (125)		15 (14)
6a	55 (22)	0 (0)	0 (0)	55 (22)	15 (5)	2 (2)
6b	50 (20)	4 (2)	1 (<1)	45 (18)	12 (4)	1 (1)
6c	5 (2)	0 (0)	1 (<1)	4 (2)	20 (6)	<1 (<1)
6d	6 (2)	0 (0)	0 (0)	6 (2)	15 (5)	<1 (<1)
	116 (47)	4 (2)	2 (1)	110 (45)		3 (3)
	580 (235)	149 (60)	7 (3)	420 (170)		18 (16)
Stanhope Township						
7	205 (83)	70 (28)	10 (4)	125 (51)	20 (6)	6 (5)
8a	110 (45)	40 (16)	20 (8)	50 (20)	20 (6)	2 (2)
8b	25 (10)	10 (4)	0 (0)	15 (6)	20 (6)	<1 (<1)
	135 (55)	50 (20)	20 (8)	65 (26)		2 (2)
9	42 (17)	1 (<1)	0 (0)	41 (17)	35 (11)	4 (4)
10	370 (150)	70 (28)	5 (2)	295 (119)	20 (6)	15 (14)
	750 (305)	191 (77)	35 (14)	530 (214)		27 (24)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
Guilford Geographic Township						
11	400 (162)	78 (32)	48 (19)	275 (111)	20 (6)	14 (13)
12a	102 (41)	42 (17)	12 (5)	48 (19)	20 (6)	2 (2)
12b	169 (68)	128 (52)	0 (0)	41 (17)	15 (5)	2 (2)
12c	16 (6)	0 (0)	1 (<1)	15 (6)	25 (8)	<1 (<1)
12d	4 (2)	0 (0)	0 (0)	4 (2)	25 (8)	<1 (<1)
	290 (117)	170 (69)	13 (5)	108 (44)		4 (4)
	690 (280)	248 (100)	61 (25)	385 (156)		18 (16)
TOTAL FOR DORSET-EAGLE LAKE MAP AREA:						
	3900 (1580)	1070 (435)	135 (55)	2700 (1090)		100 (91)
HALIBURTON-MINDEN MAP AREA						
Minden Geographic Township						
13a	115 (47)	23 (9)	2 (1)	90 (36)	25 (8)	6 (5)
13b	50 (20)	0 (0)	5 (2)	45 (18)	25 (8)	3 (3)
13c	110 (45)	0 (0)	5 (2)	105 (42)	15 (5)	4 (4)
13d	32 (13)	0 (0)	12 (5)	20 (8)	15 (5)	<1 (<1)
	305 (123)	23 (9)	24 (10)	260 (105)		13 (12)
14a	15 (6)	0 (0)	0 (0)	15 (6)	20 (6)	<1 (<1)
14b	115 (47)	32 (13)	3 (1)	80 (32)	20 (6)	4 (4)
	130 (53)	32 (13)	3 (1)	95 (38)		4 (4)
15a	38 (15)	0 (0)	1 (<1)	37 (15)	30 (9)	3 (3)
15b	28 (11)	0 (0)	3 (1)	25 (10)	15 (5)	<1 (<1)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
15d	50 (20)	7 (3)	3 (1)	40 (16)	20 (6)	2 (2)
15e	170 (69)	19 (8)	1 (<1)	150 (61)	12 (4)	4 (4)
	285 (115)	26 (11)	8 (3)	250 (101)		9 (8)
	720 (290)	81 (33)	35 (14)	600 (245)		26 (24)
Dysart Geographic Township						
16a	46 (19)	5 (2)	18 (7)	23 (9)	20 (6)	1 (1)
16b	97 (39)	7 (3)	54 (22)	36 (15)	20 (6)	2 (2)
16c	53 (21)	0 (0)	0 (0)	53 (21)	20 (6)	3 (3)
	196 (79)	12 (5)	72 (29)	112 (45)		6 (5)
Lutterworth Township						
17	24 (10)	4 (2)	3 (1)	17 (7)	35 (11)	1 (1)
Snowdon Township						
15a	13 (5)	0 (0)	0 (0)	13 (5)	30 (9)	<1 (<1)
15c	75 (30)	0 (0)	15 (6)	60 (24)	30 (9)	4 (4)
15e	15 (6)	0 (0)	3 (1)	12 (5)	12 (4)	<1 (<1)
	103 (42)	0 (0)	18 (7)	85 (34)		4 (4)
18	70 (28)	2 (1)	6 (2)	62 (25)	20 (6)	3 (3)
19a	115 (47)	10 (4)	5 (2)	100 (40)	12 (4)	3 (3)
19b	85 (34)	9 (4)	1 (0.4)	75 (30)	30 (9)	6 (5)
19c	150 (61)	0 (0)	10 (4)	140 (57)	15 (5)	5 (5)
19d	85 (34)	10 (4)	0 (0)	75 (30)	15 (5)	3 (3)
	435 (176)	29 (12)	16 (6)	390 (158)		17 (15)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
20a	6 (2)	0 (0)	0 (0)	6 (2)	12 (4)	<1 (<1)
20b	4 (2)	0 (0)	0 (0)	4 (2)	30 (9)	<1 (<1)
20c	26 (11)	0 (0)	0 (0)	26 (11)	15 (5)	1 (1)
20d	5 (2)	0 (0)	0 (0)	5 (2)	25 (8)	<1 (<1)
20e	13 (5)	0 (0)	0 (0)	13 (5)	18 (5)	<1 (<1)
	54 (22)	0 (0)	0 (0)	54 (22)		1 (1)
	660 (265)	31 (13)	40 (16)	590 (239)		25 (23)
Glamorgan Township						
	- NONE -					
TOTAL FOR HALIBURTON-MINDEN MAP AREA:						
	1600 (650)	128 (52)	150 (61)	1320 (530)		58 (53)
TORY HILL-CARDIFF MAP AREA						
Dudley Geographic Township						
21	390 (158)	222 (90)	14 (6)	154 (62)	10 (3)	4 (4)
22	265 (107)	74 (30)	2 (1)	189 (76)	12 (4)	6 (5)
	660 (265)	300 (121)	16 (6)	345 (140)		10 (9)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
Monmouth Township						
23b	475 (192)	242 (98)	23 (9)	210 (85)	15 (5)	8 (7)
23c	200 (81)	91 (37)	12 (5)	97 (39)	15 (5)	4 (4)
23d	32 (13)	20 (8)	6 (2)	6 (2)	12 (4)	<1 (<1)
23e	57 (23)	25 (10)	9 (4)	23 (9)	15 (5)	<1 (<1)
	760 (310)	380 (154)	50 (20)	335 (136)		12 (11)
24	17 (7)	0 (0)	0 (0)	17 (7)	30 (9)	1 (1)
	780 (315)	380 (154)	50 (20)	350 (142)		13 (12)
Cardiff Township						
23a	202 (82)	141 (57)	14 (6)	47 (19)	15 (5)	2 (2)
25a	24 (10)	7 (3)	0 (0)	17 (7)	30 (9)	1 (1)
25b	166 (67)	62 (25)	2 (1)	102 (41)	25 (8)	6 (5)
	190 (77)	69 (28)	2 (1)	119 (48)		7 (6)
26a	71 (29)	10 (4)	7 (3)	54 (22)	40 (12)	5 (4)
26b	65 (26)	15 (6)	5 (2)	45 (18)	20 (6)	2 (2)
	136 (55)	25 (10)	12 (5)	99 (40)		7 (6)
	530 (214)	235 (95)	28 (11)	265 (107)		16 (14)
Bicroft Township						
			- NONE -			
TOTAL FOR TORY HILL-CARDIFF MAP AREA:						
	1970 (800)	920 (370)	94 (38)	960 (390)		39 (35)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCES AREAS, PART OF HALIBURTON COUNTY.

1 Deposit No.	2 Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
TOTAL FOR STUDY AREA:						
	7500 (3050)	2120 (860)	380 (154)	5000 (2020)		197 (179)

TABLE 4. SUMMARY OF TEST HOLE DATA, PART OF HALIBURTON COUNTY.

DORSET-EAGLE LAKE MAP AREA

Test Hole Number: HB-TH-1
Location: Livingstone Geographic Township
Lots 8 and 9, Concession 11
Elevation: Approx. 1400 feet (425 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-5.0 (0-1.5)	bouldery silty sand till; maximum clast size 3 feet (1 m); bedrock at base of hole

Test Hole Number: HB-TH-2
Location: Livingstone Geographic Township
Lot 5, Concessions 9,10
Elevation: Approx. 1400 feet (425 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-3.0 (0-0.9)	clean, fine to medium sand
3.0-4.0 (0.9-1.2)	fine sand with minor medium to coarse gravel
4.0-8.0 (1.2-2.4)	fine to medium gravel
8.0-12.0 (2.4-3.7)	fine to medium sand with minor gravel

Test Hole Number: HB-TH-3
Location: Livingstone Geographic Township
Lot 10, Concession 8
Elevation: Approx. 1350 feet (410 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-4.0 (0-1.2)	cobbles and boulders

Test Hole Number: HB-TH-4
Location: McClintock Geographic Township
Lot 18, Concessions 5,6
Elevation: Approx. 1400 feet (425 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-11.5 (0-3.5)	medium to fine sand with minor coarse sand and fine gravel

Test Hole Number: HB-TH-5
Location: McClintock Geographic Township
Lot 15, Concession 3
Elevation: Approx. 1250 feet (380 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-2.5 (0-0.8)	dirty coarse gravel
2.5-8.0 (0.8-2.4)	coarse gravel with abundant cobbles and boulders
8.0-11.0 (2.4-3.4)	fine gravel with minor cobbles

Test Hole Number: HB-TH-6
Location: Sherborne Geographic Township,
Lot 19, Concession 6 (floor of pit no.49)
Elevation: Approx. 1300 feet (395 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-13.0 (0-4.0)	clean medium sand; water at base of hole

Test Hole Number: HB-TH-7
Location: Sherborne Geographic Township,
Lot 19, Concession 6 (floor of pit no. 49)
Elevation: Approx. 1300 feet (395 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-5.0 (0-1.5)	medium to coarse sand with trace fine gravel
5.0-10.0 (1.5-3.0)	medium sand

Test Hole Number: HB-TH-8
Location: Sherborne Geographic Township,
Lot 19, Concession 6 (floor of pit no.49)
Elevation: Approx. 1300 feet (395 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-6.5 (0-2.0)	fine to coarse sand; horizontally stratified and ripple laminated; minor iron staining; water at base of hole

TABLE 4. SUMMARY OF TEST HOLE DATA, PART OF HALIBURTON COUNTY.

Test Hole Number: HB-TH-9
Location: Sherborne Geographic Township
Lot 19, Concession 6 (beside pit no. 49)
Elevation: Approx. 1300 feet (395 m) a.s.l.
Date: August 5, 1986

Depth feet (metres)	Description
0-5.0 (0-1.5)	sandy gravel
5.0-8.0 (1.5-2.4)	medium sand; water at base of hole

Test Hole Number: HB-TH-10
Location: Stanhope Township
Lot 18, Concession 8
Elevation: Approx. 1150 feet (350 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-4.0 (0-1.2)	clean medium to coarse sand
4.0-10.0 (1.2-3.0)	fine sand; bedrock at base of hole

Test Hole Number: HB-TH-11
Location: Stanhope Township
Lot 16, Concession 7
Elevation: Approx. 1150 feet (350 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-2.0 (0-0.6)	dirty gravel
2.0- 7.0 (0.6-2.1)	medium sand with minor fine to medium gravel
7.0-8.0 (2.1-2.4)	fine gravel in coarse sand matrix
8.0-8.5 (2.4-2.6)	medium sand with minor fine gravel
8.5-9.0 (2.6-2.7)	silty sand
9.0-12.5 (2.7-3.8)	medium to coarse sand with trace fine gravel; water at base of hole

Test Hole Number: HB-TH-12
Location: Stanhope Township
Lot 21, Concession 2
Elevation: Approx. 1100 feet (335 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-1.0 (0-0.3)	dirty gravel with minor boulders
1.0-6.5 (0.3-2.0)	gravelly sand with minor boulders; bedrock at base of hole

HALIBURTON-MINDEN MAP AREA

Test Hole Number: HB-TH-13
Location: Dysart Geographic Township
Lot 25, Concession 3
Elevation: Approx. 1150 feet (350 m) a.s.l.
Date: August 7, 1986

Depth feet (metres)	Description
0-8.0 (0-2.4)	clean medium to fine sand
8.0-15 (2.4-4.6)	silty fine sand

Test Hole Number: HB-TH-14
Location: Snowdon Township
Lot 19, Concession 14
Elevation: Approx. 1150 feet (350 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-7.0 (0-2.1)	silty bouldery sand till

TABLE 4. SUMMARY OF TEST HOLE DATA, PART OF HALIBURTON COUNTY.

TORY HILL-CARDIFF MAP AREA

Test Hole Number: HB-TH-15
Location: Monmouth Township
Lot 4, Concession 7
Elevation: Approx. 1200 feet (365 m) a.s.l.
Date: August 7, 1986

Depth feet (metres)	Description
0-5.5 (0-1.7)	clean fine to coarse sand with trace coarse gravel
5.5-12.0 (1.7-3.7)	fine sand grading downwards into silty sand

Test Hole Number: HB-TH-16
Location: Monmouth Township
Lot 21, Concession 6
Elevation: Approx. 1150 feet (350 m) a.s.l.
Date: August 7, 1986

Depth feet (metres)	Description
0-3.5 (0-1.1)	clean fine to medium sand
3.5-5.5 (1.1-1.7)	silty fine sand
5.5-12.0 (1.7-3.7)	clean coarse sand

Test Hole Number: HB-TH-17
Location: Cardiff Township
Lot 26, Concession 2
Elevation: Approx. 1100 feet (335 m) a.s.l.
Date: August 6, 1986

Depth feet (metres)	Description
0-3.0 (0-0.9)	fine sand
3.0-4.5 (0.9-1.4)	clean coarse sand with trace fine gravel
4.5-6.0 (1.4-1.8)	medium to fine sand
6.0-16.0 (1.8-4.9)	laminated fine sand

Test Hole Number: HB-TH-18
Location: Cardiff Township
Lot 28, Concession 2
Elevation: Approx. 1100 feet (335 m) a.s.l.
Date: August 7, 1986

Depth feet (metres)	Description
0-3.0 (0-0.9)	coarse sand with trace fine gravel
3.0-6.0 (0.9-1.8)	fine sand; water at base of hole

TABLE 5. SUMMARY OF GEOPHYSICS DATA, PART OF HALIBURTON COUNTY.

DORSET-EAGLE LAKE MAP AREA

Line Number: HB-GT-1
Line Direction: North-South
Method: Hammer Seismic
Location: Livingstone Geographic Township
Lot 5, Concessions 9 and 10
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1500 ft/sec (455 m/sec)
V_2= 12,000 ft/sec (3650 m/sec)
Layer Thickness: D_3= 11 ft (3.4 m)
Interpretation: Approximately 11 feet (3.4 m) of sand and gravel over bedrock.

Line Number: HB-GT-2
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Livingstone Geographic Township
Lot 7, Concessions 9 and 10
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 2650 ft/sec (810 m/sec)
V_2= 6000 ft/sec (1830 m/sec)
Layer Thickness: D_1= 7 ft (2.1 m)
Interpretation: Approximately 7 feet (2.1 m) of gravel or till over bedrock.

Line Number: HB-GT-3
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: Livingstone Geographic Township
Lots 9 and 10, Concession 6 (floor of pit no. 13)
Elevation: Approximately 1250 feet (380 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1450 ft/sec (440 m/sec)
V_2= 5500 ft/sec (1680 m/sec)
Layer Thickness: D_1= 6 ft (1.8 m)
Interpretation: Approximately 6 feet (1.8 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-4
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: Livingstone Geographic Township
Lots 9 and 10, Concession 1
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1130 ft/sec (345 m/sec)
V_2= 4000 ft/sec (1220 m/sec)
Layer Thickness: D_1= 10 ft (3 m)
Interpretation: Approximately 10 feet (3 m) of sand over moist sand to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-5
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: McClintock Geographic Township
Lots 31 and 32, Concession 13
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1300 ft/sec (395 m/sec)
V_2= 21,000 ft/sec (6400 m/sec)
Layer Thickness: D_1= 35 ft (10.7 m)
Interpretation: Approximately 35 feet (10.7 m) of sand and gravel over bedrock.

Line Number: HB-GT-6
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: McClintock Geographic Township
Lots 31 and 32, Concession 13 (floor of pit no. 18)
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1420 ft/sec (430 m/sec)
V_2= 5500 ft/sec (1680 m/sec)
Layer Thickness: D_1= 33 ft (10 m)
Interpretation: Approximately 33 feet (10 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

TABLE 5. SUMMARY OF GEOPHYSICS DATA, PART OF HALIBURTON COUNTY.

Line Number: HB-GT-7
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: McClintock Geographic Township
Lots 30 and 31, Concession 12
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1 = 1460 ft/sec (445 m/sec)
	V_2 = 24,000 ft/sec (7300 m/sec)
Layer Thickness:	D_1 = 9 ft (2.7 m)

Interpretation: Approximately 9 feet (2.7 m) of sand and gravel over an irregular bedrock surface.

Line Number: HB-GT-8
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: McClintock Geographic Township
Lot 7, Concession 12
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1 = 1430 ft/sec (435 m/sec)
	V_2 = 4300 ft/sec (1310 m/sec)
Layer Thickness:	D_1 = 7 ft (2.1 m)

Interpretation: Approximately 7 feet (2.1 m) of sand and gravel over moist sand and gravel or till to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-9
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: McClintock Geographic Township
Lots 5 and 6, Concession 11 (floor of pit no. 25)
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1 = 1570 ft/sec (480 m/sec)
	V_2 = 4550 ft/sec (1390 m/sec)
Layer Thickness:	D_1 = 8 ft (2.4 m)

Interpretation: Approximately 8 feet (2.4 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-10
Line Direction: North-South
Method: Hammer Seismic
Location: McClintock Geographic Township
Lot 18, Concession 5 (floor of pit no. 31)
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1 = 1140 ft/sec (350 m/sec)
	V_2 = 18,000 ft/sec (5500 m/sec)
Layer Thickness:	D_1 = 23 ft (7 m)

Interpretation: Approximately 23 feet (7 m) of sand over bedrock.

Line Number: HB-GT-11
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: McClintock Geographic Township
Lot 14, Concession 2 (floor of pit no. 35)
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1 = 1700 ft/sec (520 m/sec)
	V_2 = 7000 ft/sec (2130 m/sec)
Layer Thickness:	D_1 = 29 ft (8.8 m)

Interpretation: Approximately 29 feet (8.8 m) of sand and gravel over bedrock.

Line Number: HB-GT-12
Line Direction: Southwest-Northeast
Method: Hammer Seismic
Location: McClintock Geographic Township
Lots 14 and 15, Concession 2
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1 = 1460 ft/sec (445 m/sec)
	V_2 = 12,000 ft/sec (3650 m/sec)
Layer Thickness:	D_1 = 17 ft (5.2 m)

Interpretation: Approximately 17 feet (5.2 m) of sand and gravel over an irregular bedrock surface.

TABLE 5. SUMMARY OF GEOPHYSICS DATA, PART OF HALIBURTON COUNTY.

Line Number: HB-GT-13
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Stanhope Township
Lot 18, Concession 8 (floor of pit no. 56)
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1350 ft/sec (410 m/sec)
V_2 = 13,300 ft/sec (4050 m/sec)
Layer Thickness: D_1 = 11 ft (3.4 m)
Interpretation: Approximately 11 feet (3.4 m) of sand over an irregular bedrock surface.

Line Number: HB-GT-14
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Stanhope Township
Lot 27, Concessions 6 and 7
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1320 ft/sec (400 m/sec)
V_2 = 21,000 ft/sec (6400 m/sec)
Layer Thickness: D_1 = 19 ft (5.8 m)
Interpretation: Approximately 19 feet (5.8 m) of sand and gravel over bedrock.

Line Number: HB-GT-15
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: Stanhope Township
Lot 31, Concession 7
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:
Number of Layers: 3
Layer Velocities: V_1 = 1150 ft/sec (350 m/sec)
V_2 = 3100 ft/sec (940 m/sec)
V_3 = 5300 ft/sec (1620 m/sec)
Layer Thickness: D_1 = 10 ft (3 m)
D_2 = 16 ft (4.9 m)
Interpretation: Approximately 10 feet (3 m) of sand and gravel over 16 feet (4.9 m) of denser sand and gravel or till underlain by wet granular material to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-16
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: Stanhope Township
Lot 32, Concession 6 (floor of pit no. 76)
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1500 ft/sec (455 m/sec)
V_2 = 6400 ft/sec (1950 m/sec)
Layer Thickness: D_1 = 14 ft (4.3 m)
Interpretation: Approximately 14 feet (4.3 m) of sand and gravel over bedrock.

Line Number: HB-GT-17
Line Direction: Southwest-Northeast
Method: Hammer Seismic
Location: Guilford Geographic Township
Lots 3 and 4, Concession 4
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:
Number of Layers: 1
Layer Velocities: V_1 = 1230 ft/sec (375 m/sec)
Interpretation: Sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-18
Line Direction: Northwest-Southeast
Method: Hammer Seismic
Location: Guilford Geographic Township
Lots 12 and 13, Concession 6
Elevation: Approx. 1150 feet (350 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1330 ft/sec (405 m/sec)
V_2 = 2550 ft/sec (775 m/sec)
Layer Thickness: D_1 = 5 ft (1.5 m)
Interpretation: Approximately 5 feet (1.5 m) of sand and gravel over denser sand and gravel to a minimum depth of 30 feet (9.1 m).

TABLE 5. SUMMARY OF GEOPHYSICS DATA, PART OF HALIBURTON COUNTY.

HALIBURTON-MINDEN MAP AREA

Line Number: HB-GT-19
Line Direction: East-West
Method: Hammer Seismic
Location: Minden Geographic Township
Lots 15 and 16, Concession 11
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1= 1270 ft/sec (385 m/sec)
	V_2= 18,000 ft/sec (5500 m/sec)
Layer Thickness:	D_1= 9 ft (2.7 m)

Interpretation: Approximately 9 feet (2.7 m) of sand and gravel over bedrock.

Line Number: HB-GT-20
Line Direction: North-South
Method: Hammer Seismic
Location: Minden Geographic Township
Lot 2, Concession 11, (floor of pit no. 20)
Elevation: Approximately 1050 feet (320 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1= 1140 ft/sec (350 m/sec)
	V_2= 4850 ft/sec (1480 m/sec)
Layer Thickness:	D_1= 4 ft (1.2 m)

Interpretation: Approximately 4 feet (1.2 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-21
Line Direction: North-South
Method: Hammer Seismic
Location: Minden Geographic Township
Lot 1, Concession 8
Elevation: Approximately 1000 feet (305 m) a.s.l.
Seismic Data:

Number of Layers:	3
Layer Velocities:	V_1= 1200 ft/sec (365 m/sec)
	V_2= 2250 ft/sec (690 m/sec)
	V_3= 5000 ft/sec (1520 m/sec)
Layer Thickness:	D_1= 9 ft (2.7 m)
	D_2= 24 ft (7.3 m)

Interpretation: Approximately 9 feet (2.7 m) of sand and gravel over 24 feet (7.3 m) of denser sand and gravel. Below this the material is wet, and extends to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-22
Line Direction: North-South
Method: Hammer Seismic
Location: Minden Geographic Township
Lot 8, Concession 4
Elevation: Approximately 1000 feet (305 m) a.s.l.
Seismic Data:

Number of Layers:	1
Layer Velocities:	V_1= 1300 ft/sec (395 m/sec)

Interpretation: Sand to a minimum depth of 30 feet (9.1 m).

Line Number: HB-GT-23
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Dysart Geographic Township
Lot 25, Concessions 3 and 4
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1= 1330 ft/sec (405 m/sec)
	V_2= 6000 ft/sec (1830 m/sec)
Layer Thickness:	D_1= 8 ft (2.4 m)

Interpretation: Approximately 8 feet (2.4 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-24
Line Direction: North-South
Method: Hammer Seismic
Location: Snowdon Township
Lots 11 and 12, Concession 14
Elevation: Approximately 1150 feet (350 m) a.s.l.
Seismic Data:

Number of Layers:	3
Layer Velocities:	V_1= 1250 ft/sec (380 m/sec)
	V_2= 2440 ft/sec (740 m/sec)
	V_3= 20,000 ft/sec (6100 m/sec)
Layer Thickness:	D_1= 3 ft (0.9 m)
	D_2= 15 ft (4.6 m)

Interpretation: Approximately 3 feet (0.9 m) of sand and gravel over 15 feet (4.6 m) of denser sand and gravel or till over bedrock.

TABLE 5. SUMMARY OF GEOPHYSICS DATA, PART OF HALIBURTON COUNTY.

Line Number: HB-GT-25
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Snowdon Township
Lots 30 and 31, Concession 5
Elevation: Approximately 1100 feet (335 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1220 ft/sec (370 m/sec)
V_2= 4650 ft/sec (1420 m/sec)
Layer Thickness: D_1= 12 ft (3.7 m)
Interpretation: Approximately 12 feet (3.7 m) of dry sand over wet sand to a minimum depth of 40 feet (12.2 m).

TORY HILL-CARDIFF MAP AREA

Line Number: HB-GT-26
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Dudley Geographic Township
Lot 10, Concession 12 (in pit no. 273)
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1200 ft/sec (365 m/sec)
V_2= 5000 ft/sec (1520 m/sec)
Layer Thickness: D_1= 4 ft (1.2 m)
Interpretation: Approximately 4 feet (1.2 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-27
Line Direction: Southeast-Northwest
Method: Hammer Seismic
Location: Monmouth Township
Lot 4, Concession 7 (in pit no. 285)
Elevation: Approximately 1150 feet (350 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1270 ft/sec (385 m/sec)
V_2= 5300 ft/sec (1630 m/sec)
Layer Thickness: D_1= 8 ft (2.4 m)
Interpretation: Approximately 8 feet (2.4 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-28
Line Direction: North-South
Method: Hammer Seismic
Location: Monmouth Township
Lot 22, Concession 6
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1250 ft/sec (380 m/sec)
V_2= 20,000 ft/sec (6100 m/sec)
Layer Thickness: D_1= 11 ft (3.4 m)
Interpretation: Approximately 11 feet (3.4 m) of sand and gravel over an irregular bedrock surface.

Line Number: HB-GT-29
Line Direction: East-West
Method: Hammer Seismic
Location: Monmouth Township
Lot 27, Concession 8
Elevation: Approximately 1200 feet (365 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1500 ft/sec (460 m/sec)
V_2= 2650 ft/sec (810 m/sec)
Layer Thickness: D_1= 7 ft (2.1 m)
Interpretation: Approximately 7 feet (2.1 m) of sand and gravel over denser sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-30
Line Direction: Northeast-Southwest
Method: Hammer Seismic
Location: Cardiff Township
Lot A, Concession 17
Elevation: Approximately 1300 feet (395 m) a.s.l.
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1250 ft/sec (380 m/sec)
V_2= 4650 ft/sec (1420 m/sec)
Layer Thickness: D_1= 8 ft (2.4 m)
Interpretation: Approximately 8 feet (2.4 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

TABLE 5. SUMMARY OF GEOPHYSICS DATA, PART OF HALIBURTON COUNTY.

Line Number: HB-GT-31
Line Direction: North-South
Method: Hammer Seismic
Location: Cardiff Township
Lot 1, Concession 22 (in pit no. 312)
Elevation: Approximately 1300 feet (395 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1= 1310 ft/sec (400 m/sec)
	V_2= 5700 ft/sec (1740 m/sec)
Layer Thickness:	D_1= 17 ft (5.2 m)

Interpretation: Approximately 17 feet (5.2 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

Line Number: HB-GT-32
Line Direction: East-West
Method: Hammer Seismic
Location: Cardiff Township
Lot 15, Concession 22
Elevation: Approximately 1350 feet (410 m) a.s.l.
Seismic Data:

Number of Layers:	3
Layer Velocities:	V_1= 1130 ft/sec (345 m/sec)
	V_2= 4000 ft/sec (1220 m/sec)
	V_3= 14,000 ft/sec (4250 m/sec)
Layer Thickness:	D_1= 17 ft (5.2 m)
	D_2= 14 ft (4 m)

Interpretation: Approximately 17 feet (5.2 m) of sand and gravel over 14 feet (4 m) of denser sand and gravel over bedrock.

Line Number: HB-GT-33
Line Direction: East-West
Method: Hammer Seismic
Location: Cardiff Township
Lots 21 and 22, Concession 18
Elevation: Approximately 1400 feet (425 m) a.s.l.
Seismic Data:

Number of Layers:	2
Layer Velocities:	V_1= 1560 ft/sec (475 m/sec)
	V_2= 24,000 ft/sec (7300 m/sec)
Layer Thickness:	D_1= 13 ft (4 m)

Interpretation: Approximately 13 feet (4 m) of sand and gravel over bedrock.

TABLE 6. RESULTS OF AGGREGATE QUALITY TESTS, PART OF HALIBURTON COUNTY.

Sample No.	COARSE AGGREGATE				FINE AGGREGATE
	Petrographic Number		Magnesium Sulphate Soundness % Loss	Absorption %	Magnesium Sulphate Soundness % Loss
	Granular &16 mm Crushed	Hot Mix & Concrete			
Dorset-Eagle Lake Map Area					
Pit 13	115	172	3	0.6	12
Pit 56	104	133	5	0.73	14
Haliburton-Minden Map Area					
Pit 121	118	159	4	0.70	18
Pit 123	109	147	6	0.60	12
Pit 193	117	162	7	0.73	10.4
Pit 233	106	137	6	0.60	20
Quarry No. 1	100	135	8	0.43	-
Tory Hill-Cardiff Map Area					
Pit 296	112	157	6	0.80	-
Pit 301	103	125	7	0.70	12.3
Pit 306	104	133	5	0.80	20.7

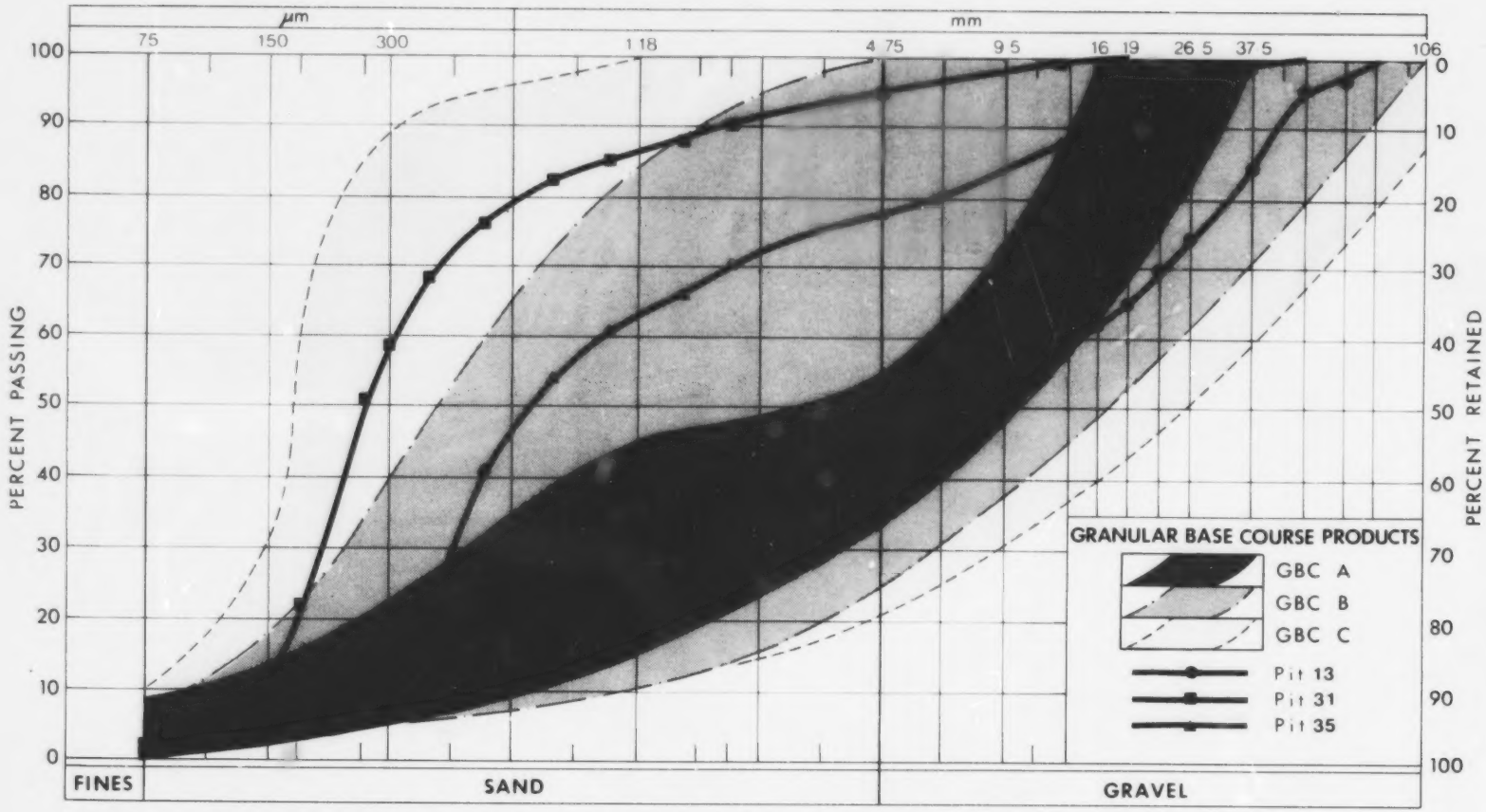


FIGURE 3a: AGGREGATE GRADING CURVES, DORSET - EAGLE LAKE MAP AREA.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

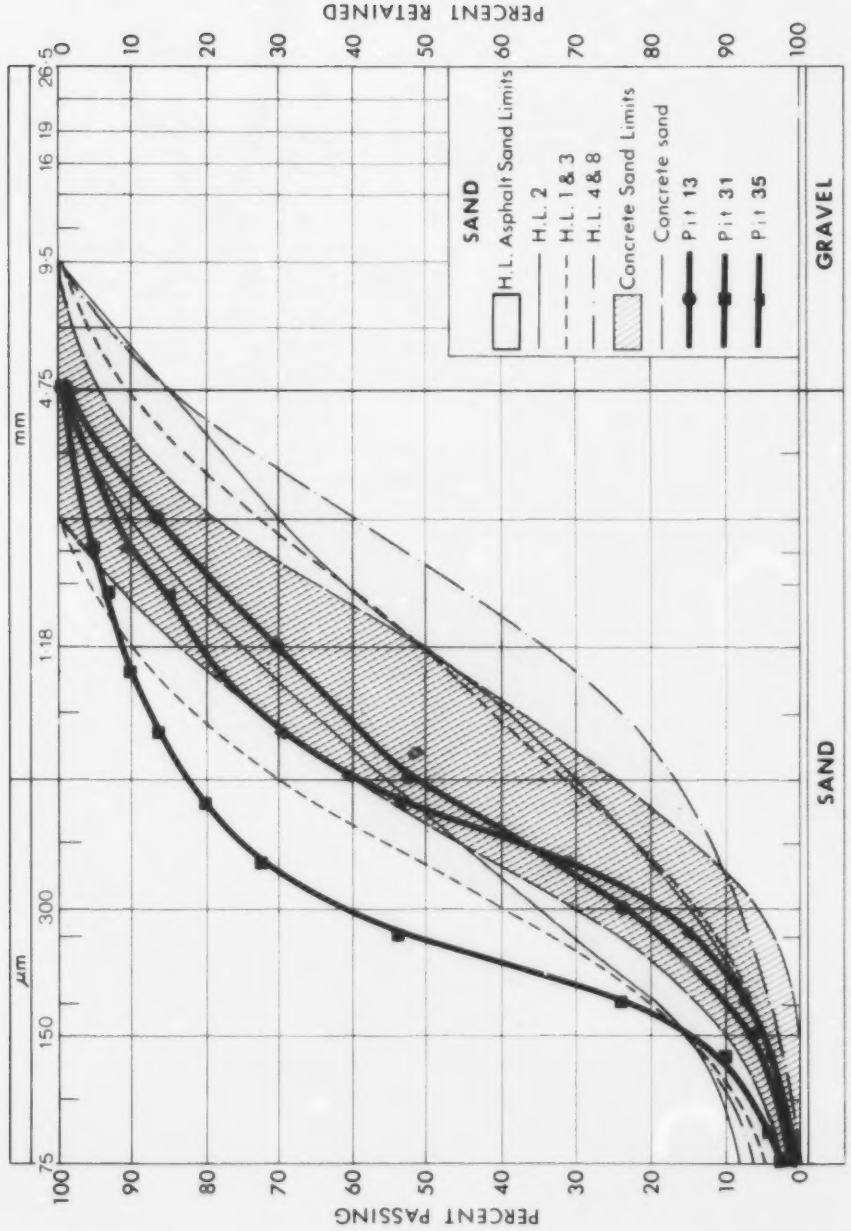


FIGURE 3b: AGGREGATE GRADING CURVES, DORSET EAGLE LAKE MAP AREA.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

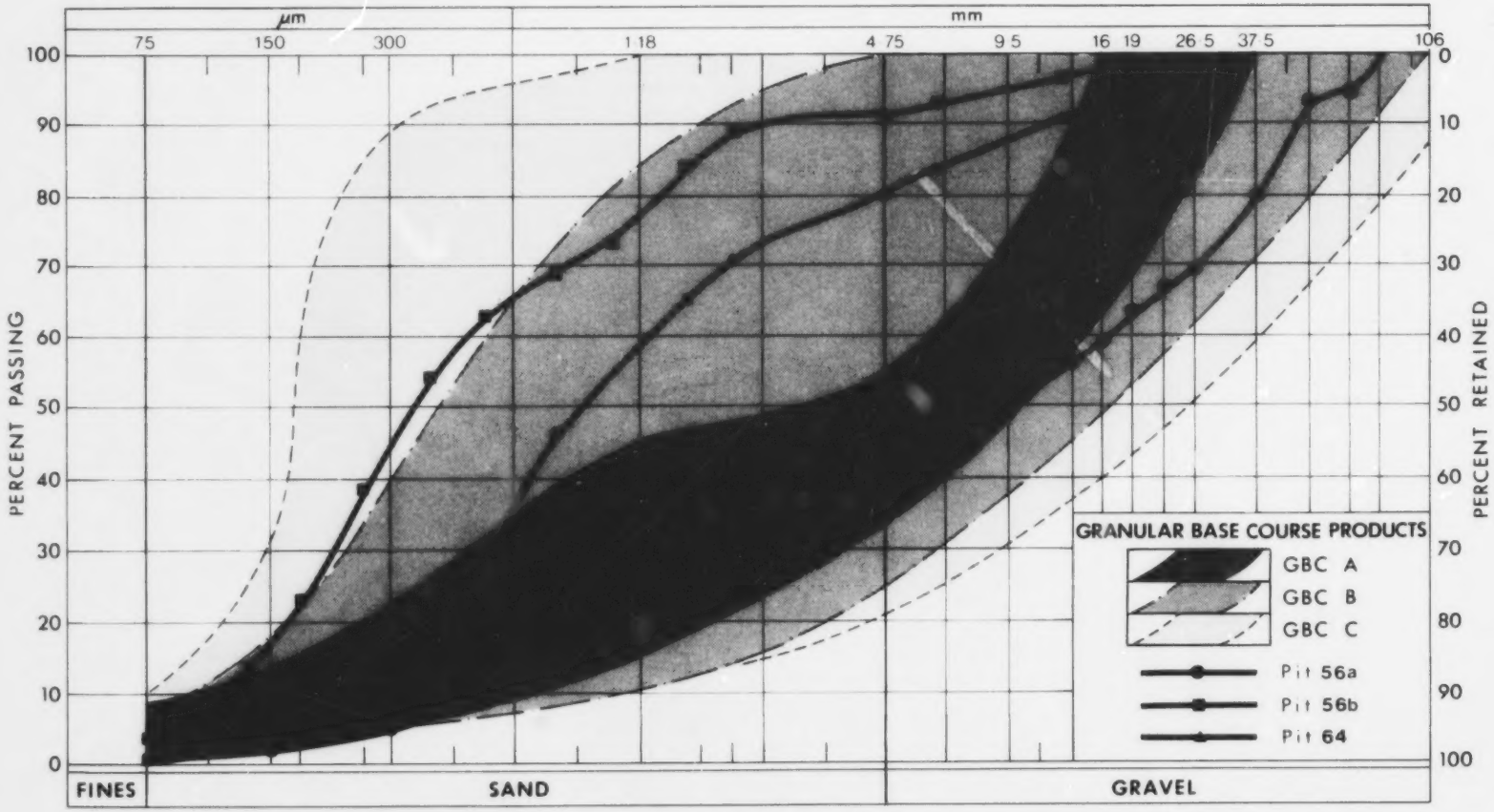


FIGURE 4a: AGGREGATE GRADING CURVES, DORSET - EAGLE LAKE MAP AREA.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

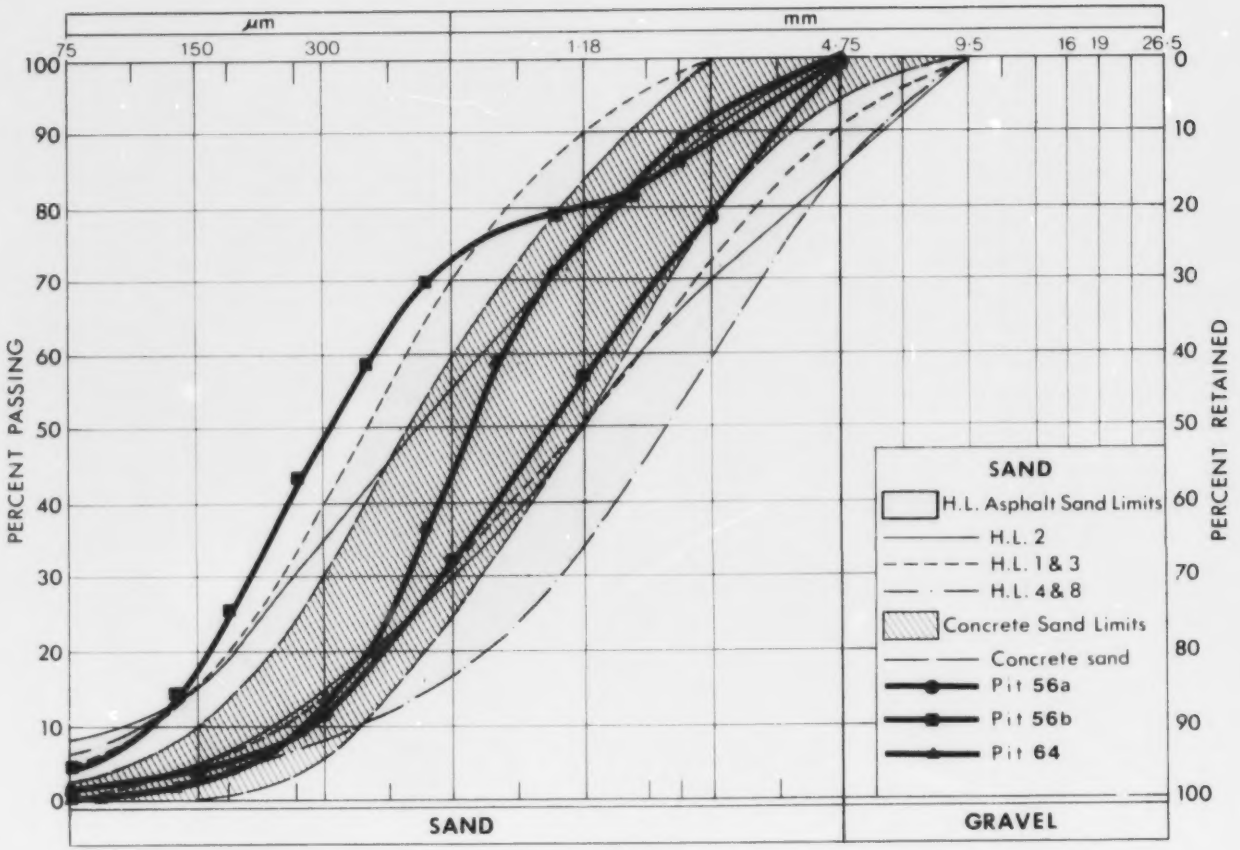


FIGURE 4b: AGGREGATE GRADING CURVES, DORSET - EAGLE LAKE MAP AREA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

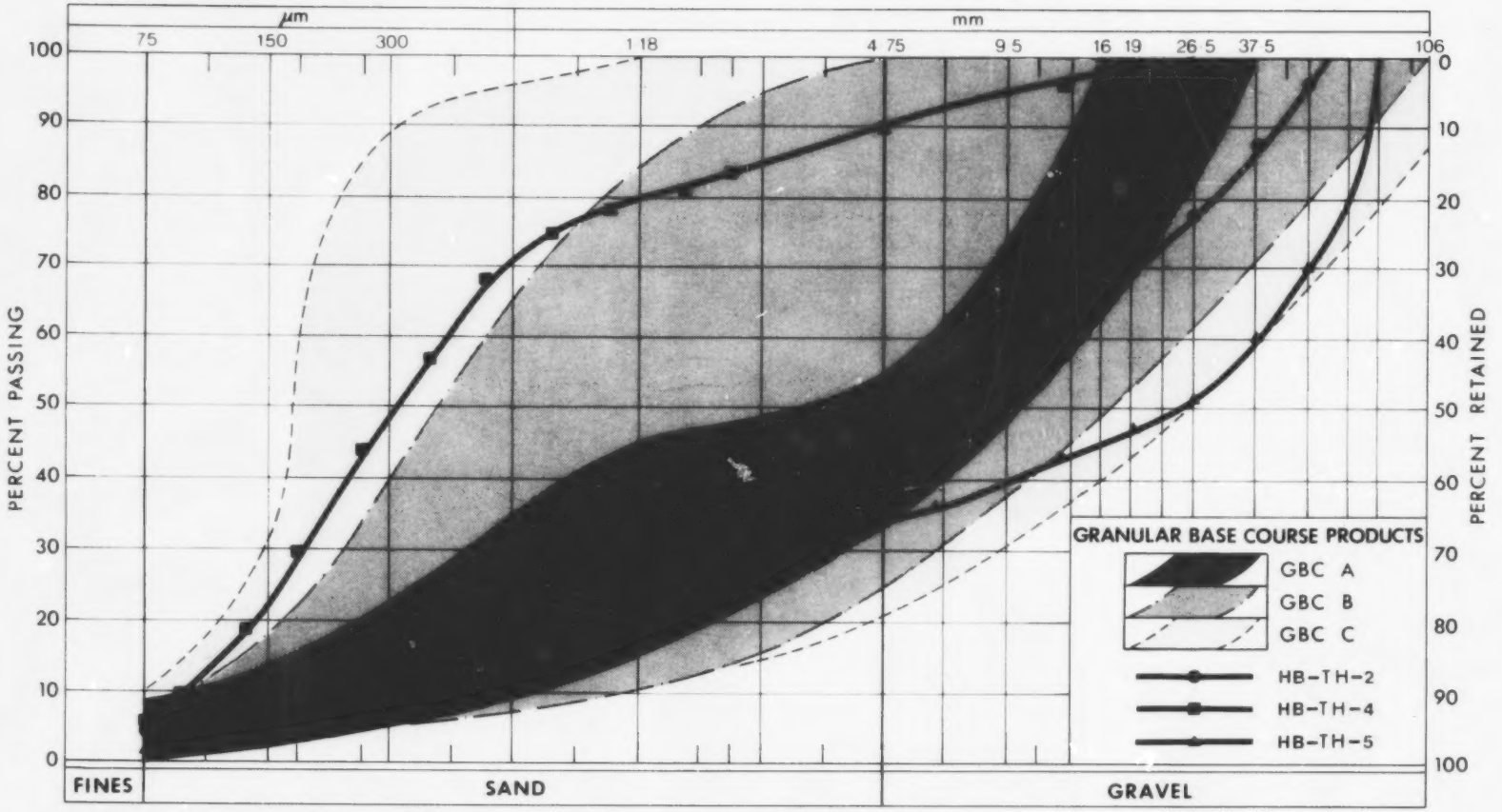


FIGURE 5a: AGGREGATE GRADING CURVES, DORSET - EAGLE LAKE MAP AREA.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

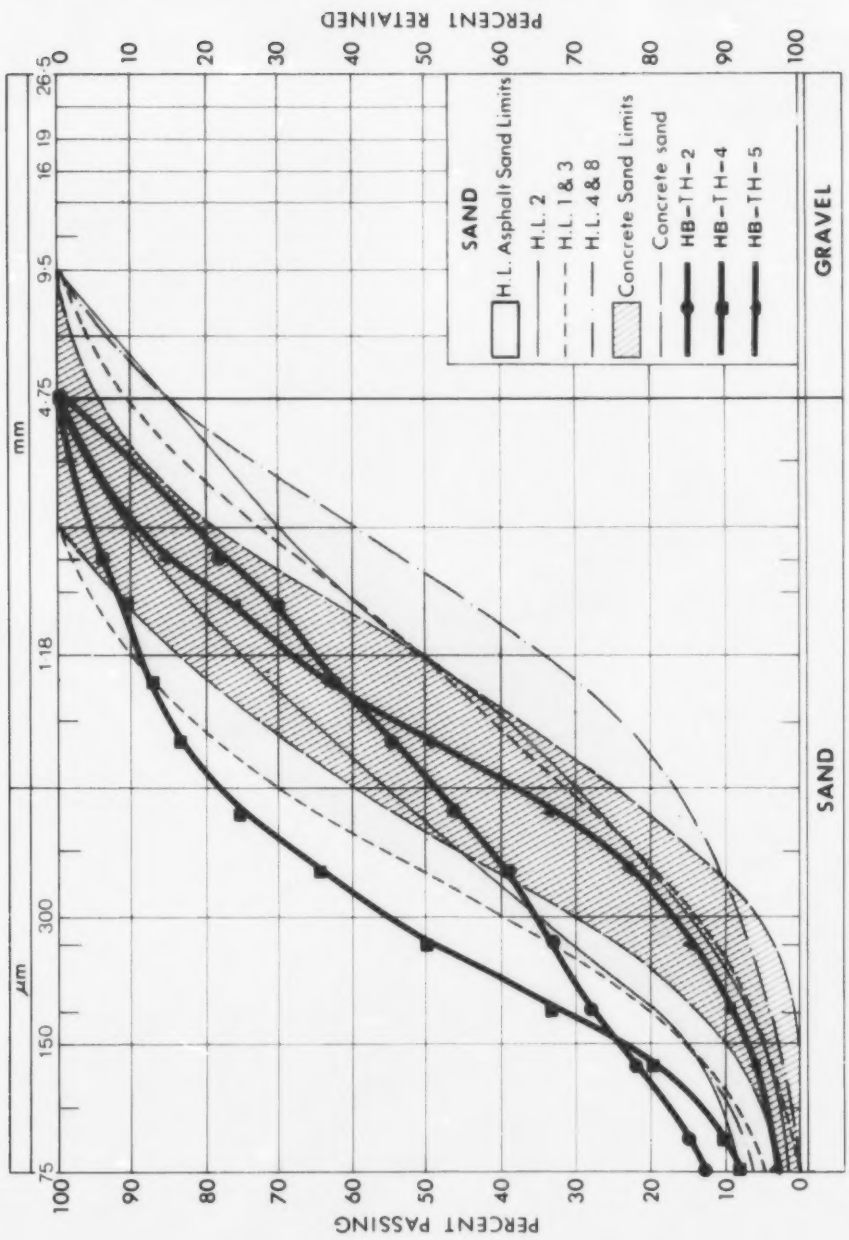


FIGURE 5b. AGGREGATE GRADING CURVES, DORSET EAGLE LAKE MAP AREA.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

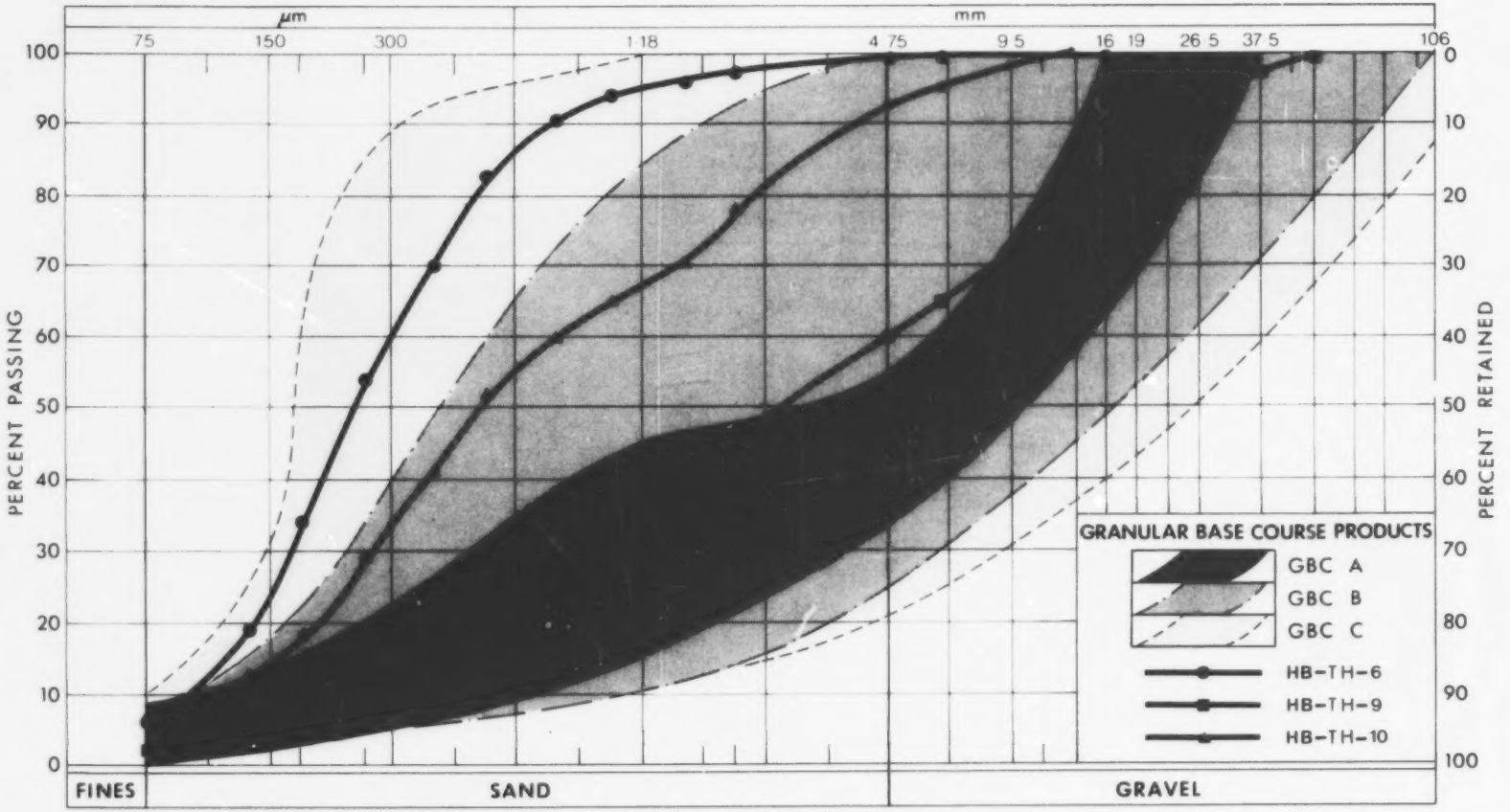


FIGURE 6a: AGGREGATE GRADING CURVES, DORSET - EAGLE LAKE MAP AREA.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

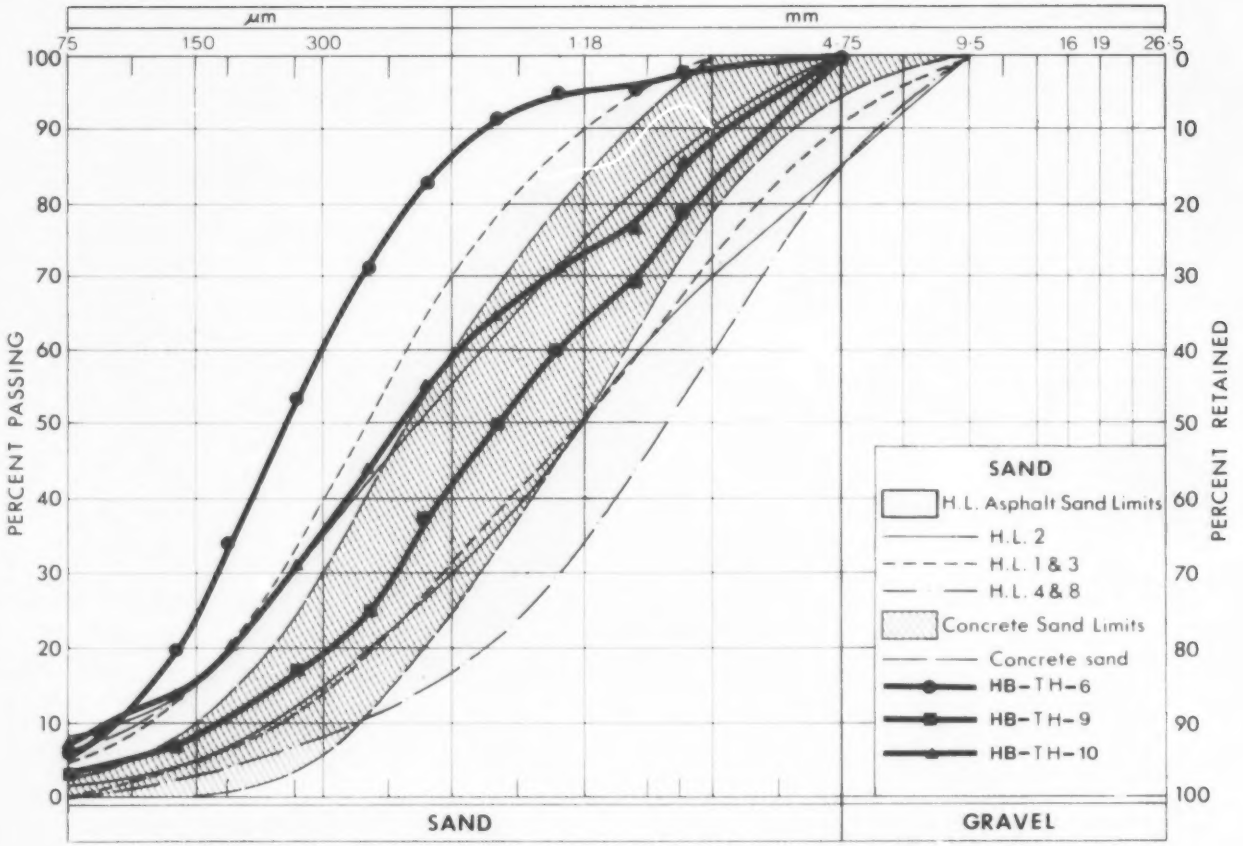


FIGURE 6b AGGREGATE GRADING CURVES, DORSET - EAGLE LAKE MAP AREA

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

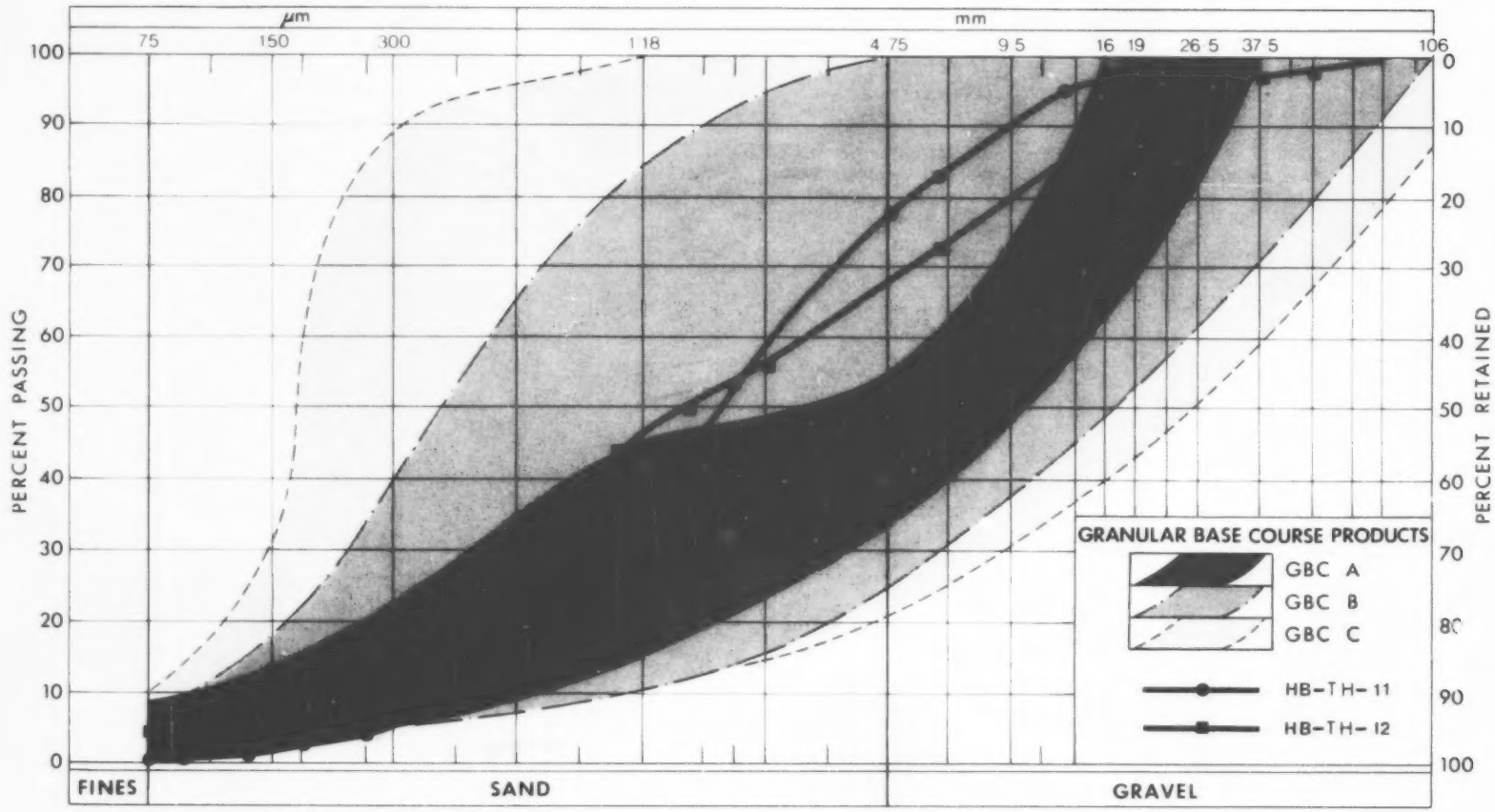


FIGURE 7a: AGGREGATE GRADING CURVES, DORSET EAGLE LAKE MAP AREA.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

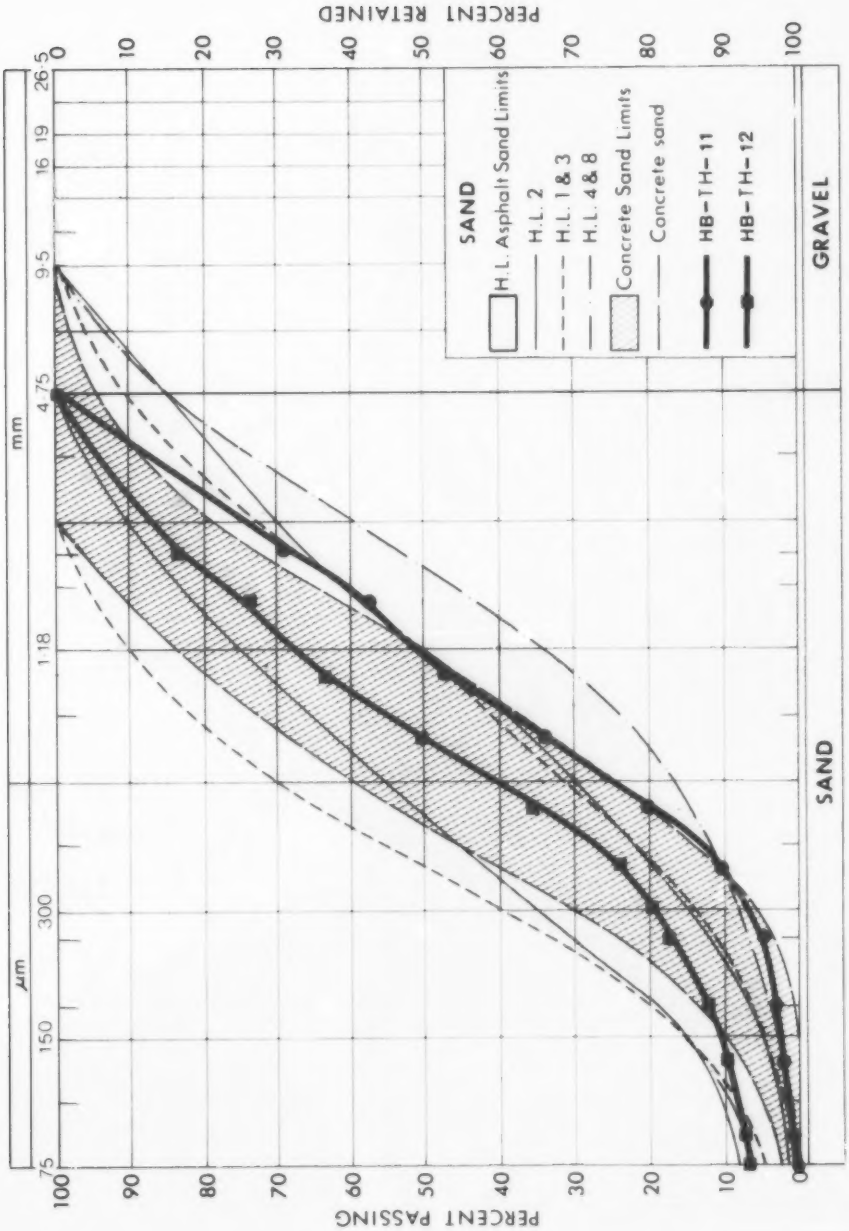


FIGURE 7b AGGREGATE GRADING CURVES, DORSET EAGLE LAKE MAP AREA.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

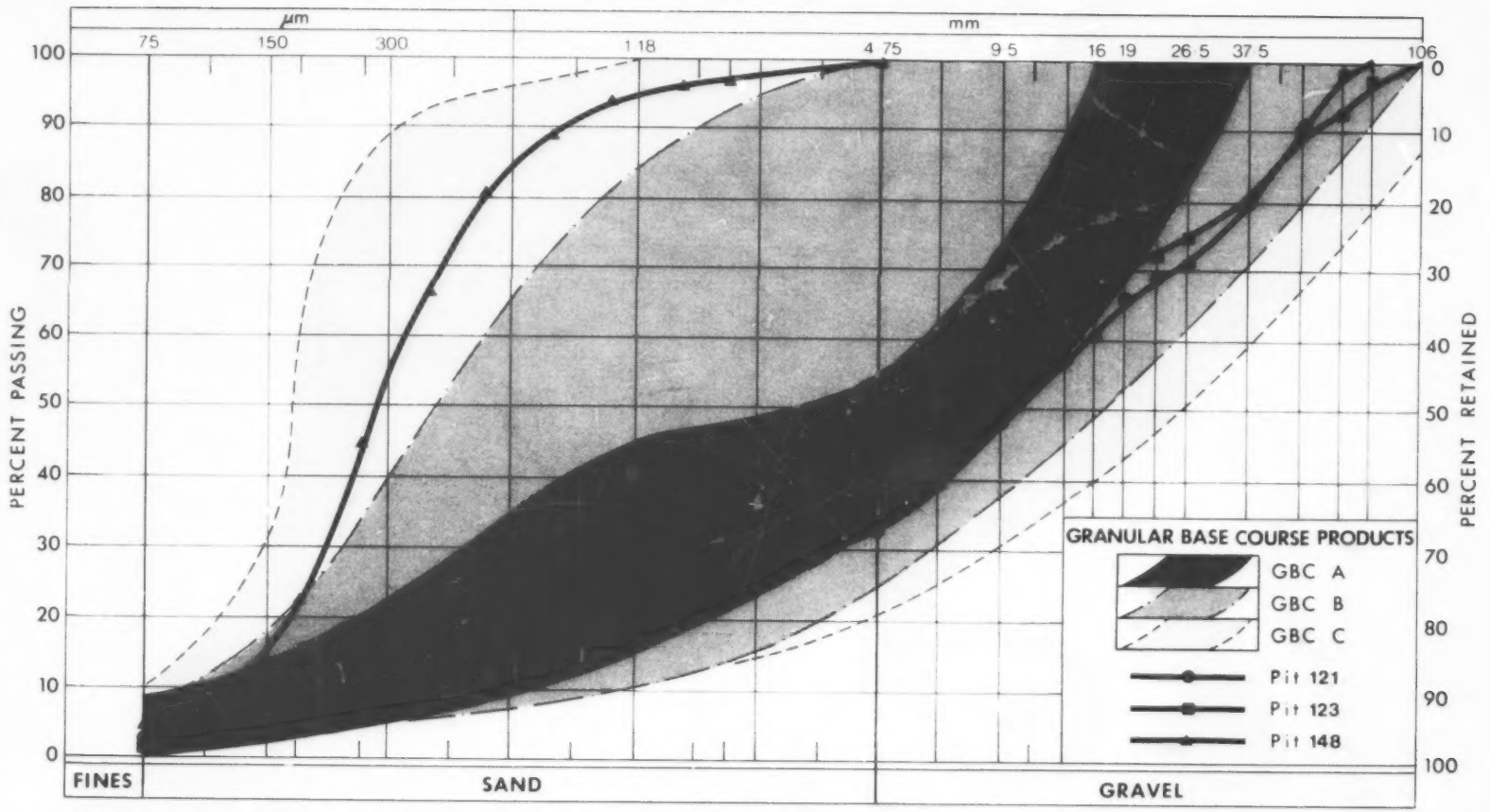


FIGURE 8a: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

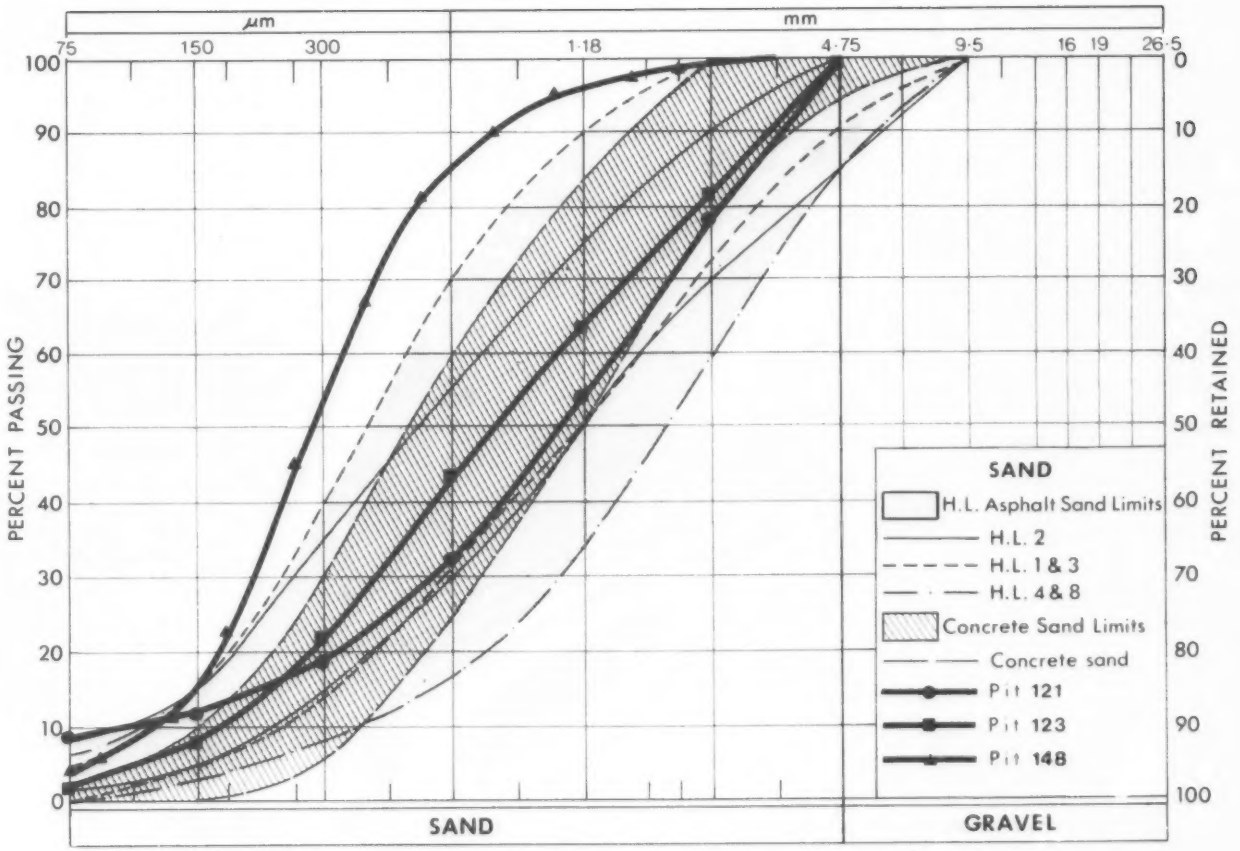


FIGURE 8b: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

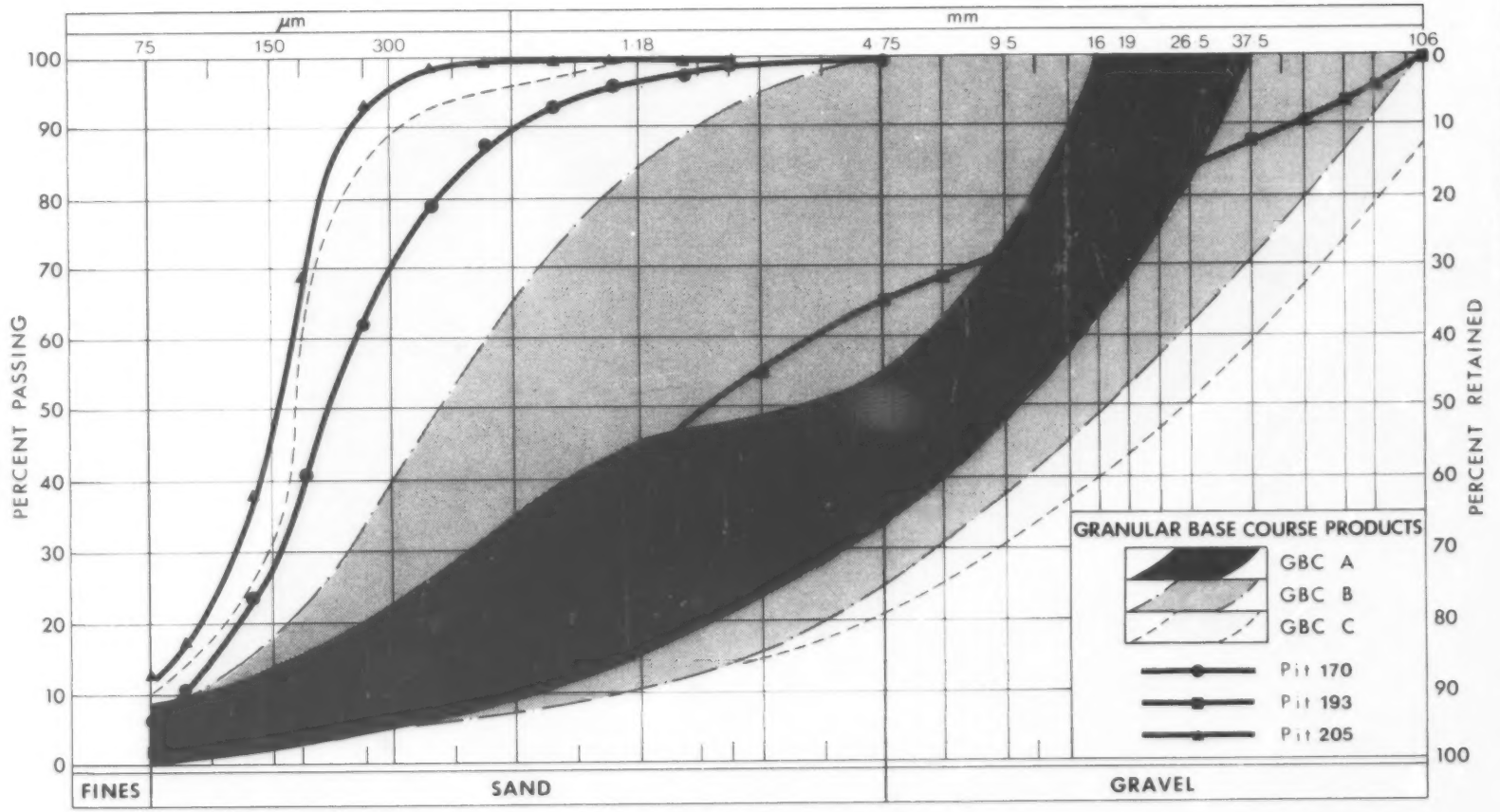


FIGURE 9a: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

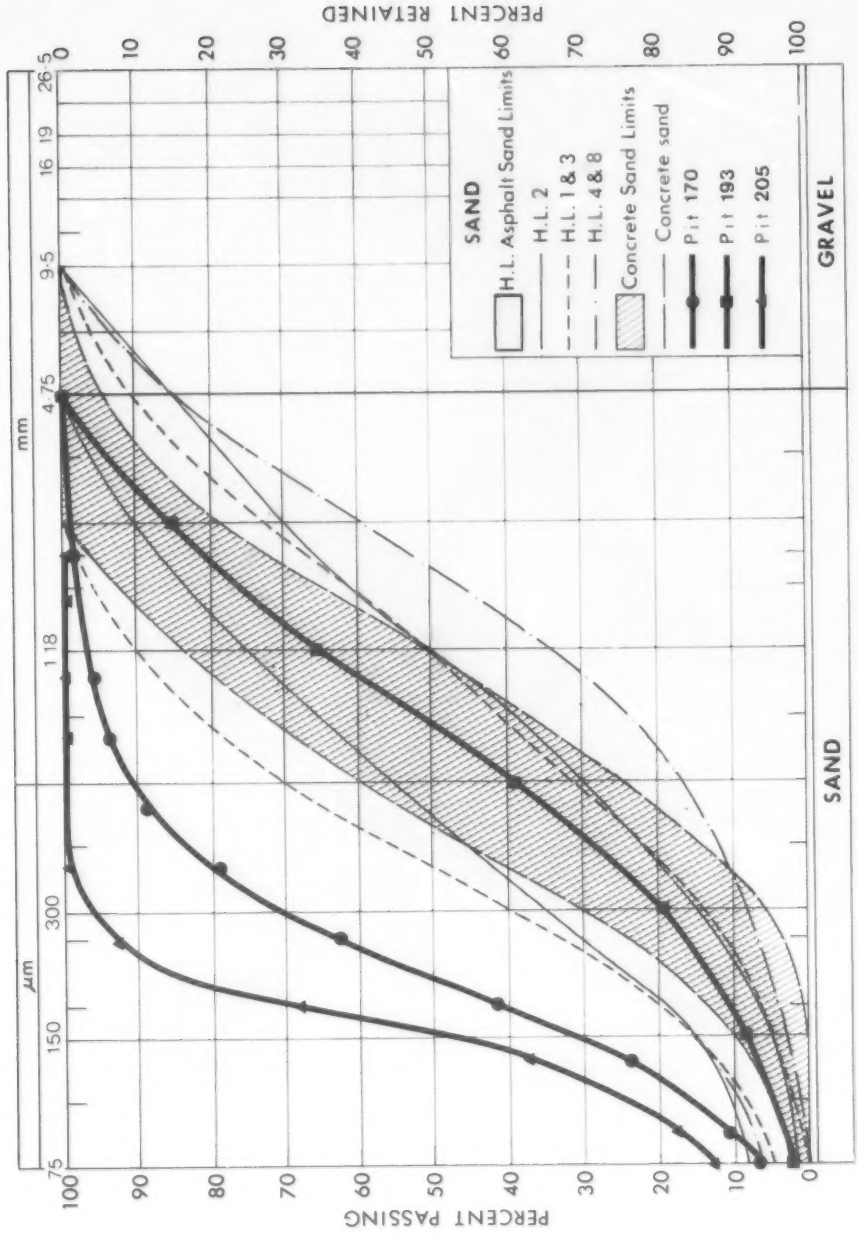


FIGURE 9b: AGGREGATE GRADING CURVES, HALIBURTON MINDEN MAP AREA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

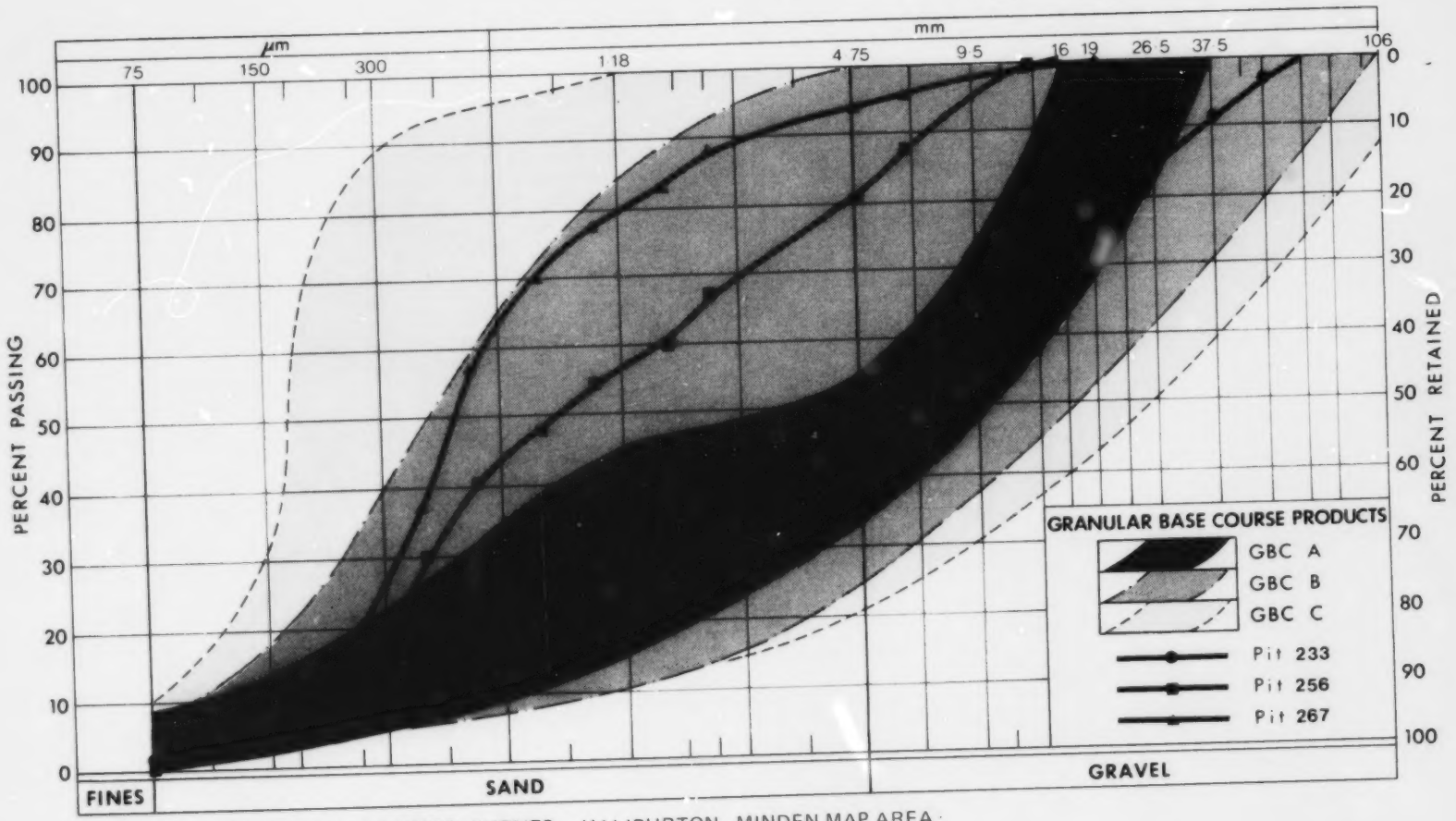


FIGURE 10a: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

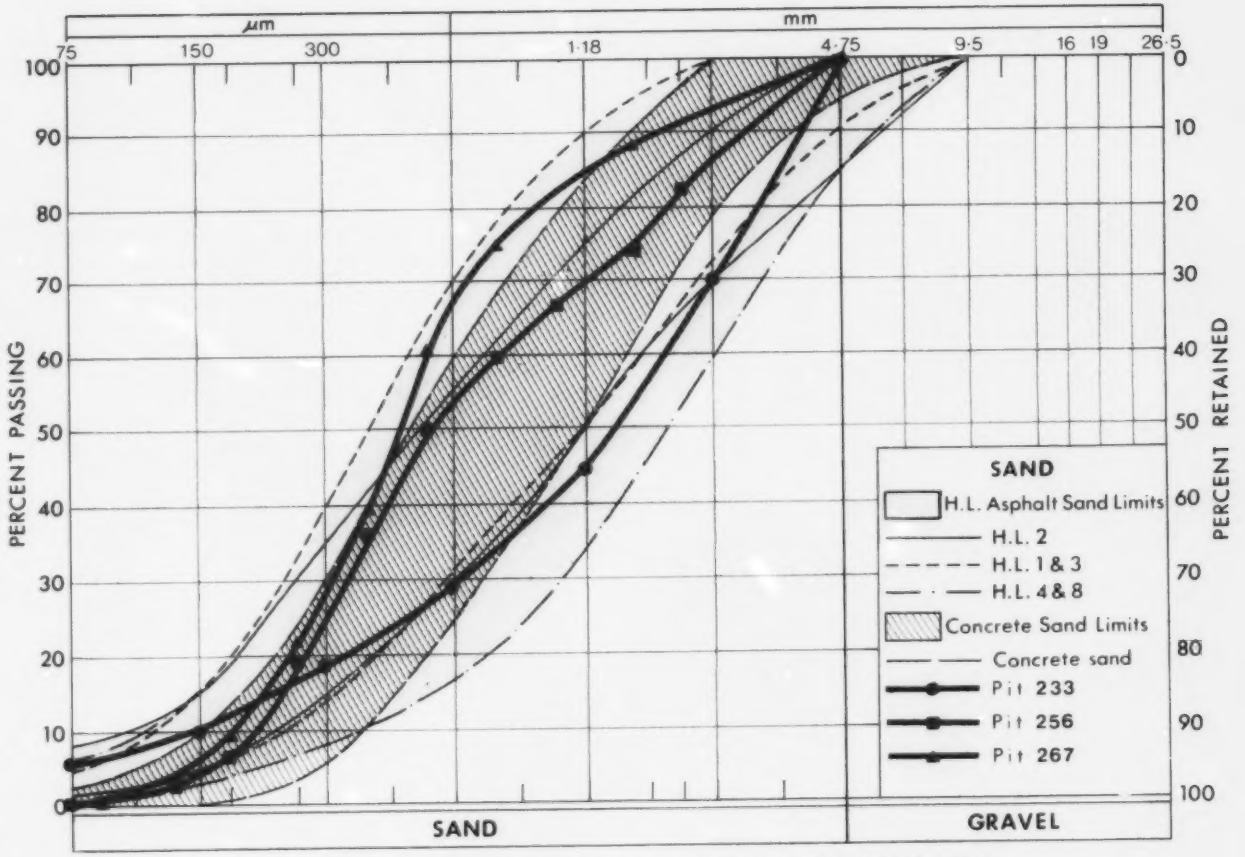


FIGURE 10b: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

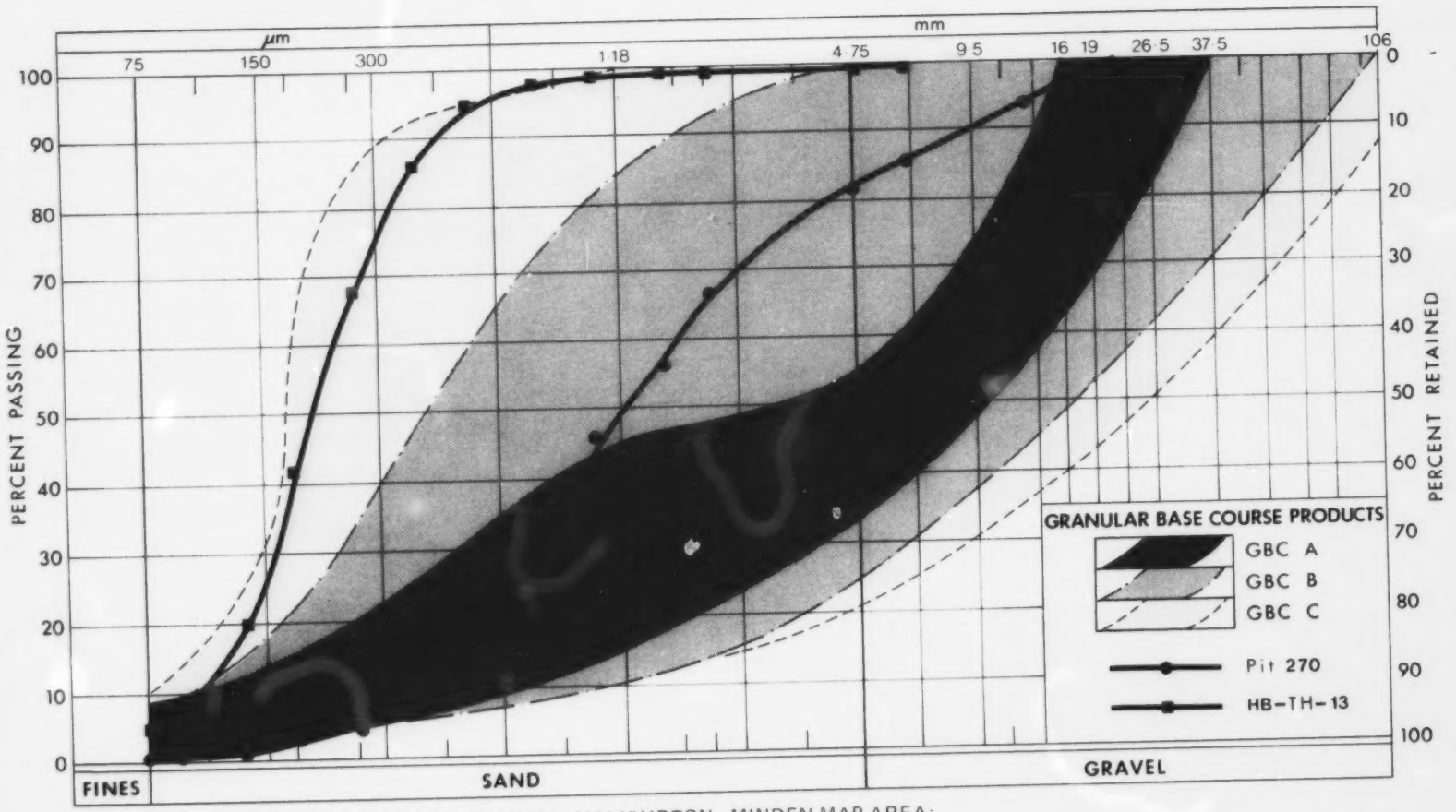


FIGURE 11a: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA:

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

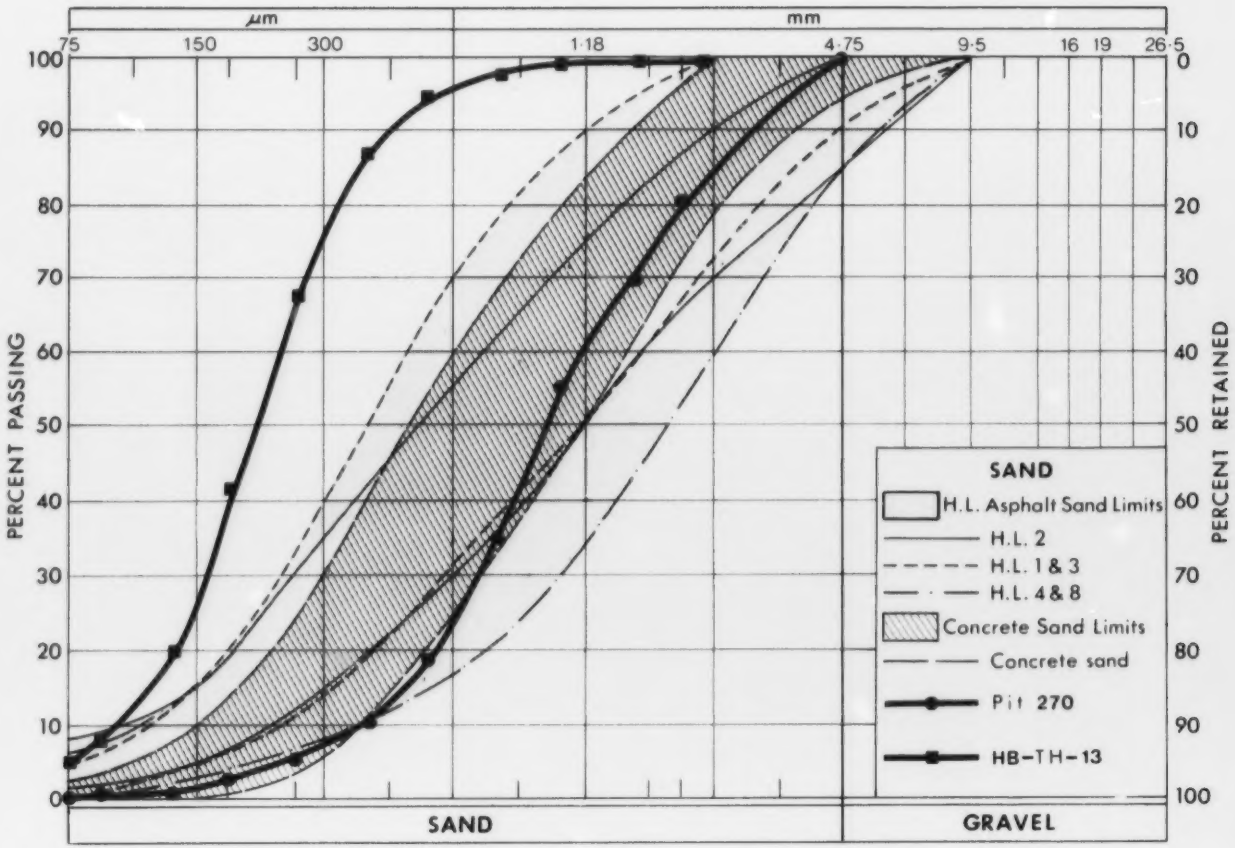


FIGURE 11b: AGGREGATE GRADING CURVES, HALIBURTON - MINDEN MAP AREA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

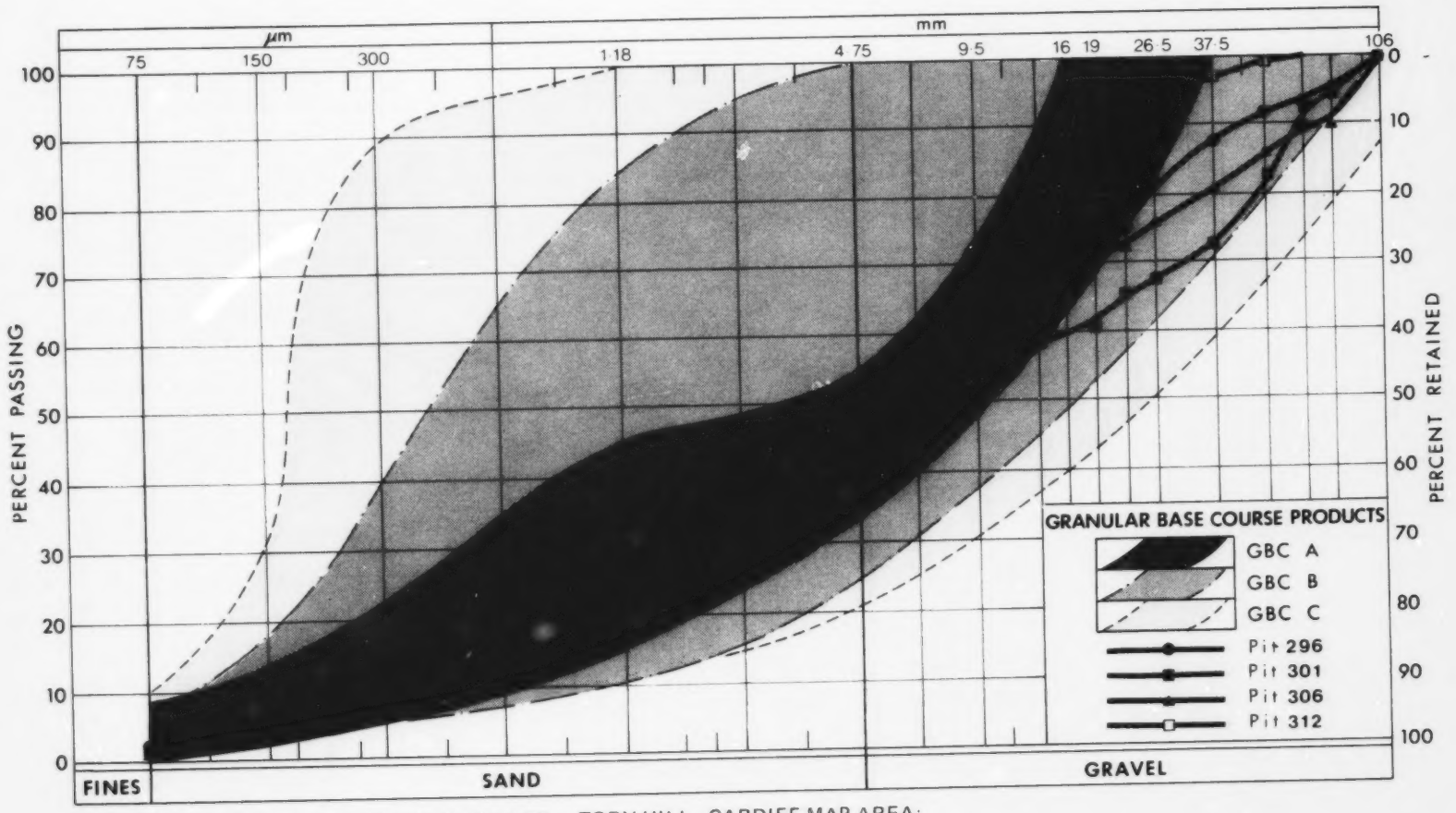


FIGURE 12a: AGGREGATE GRADING CURVES, TORY HILL - CARDIFF MAP AREA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

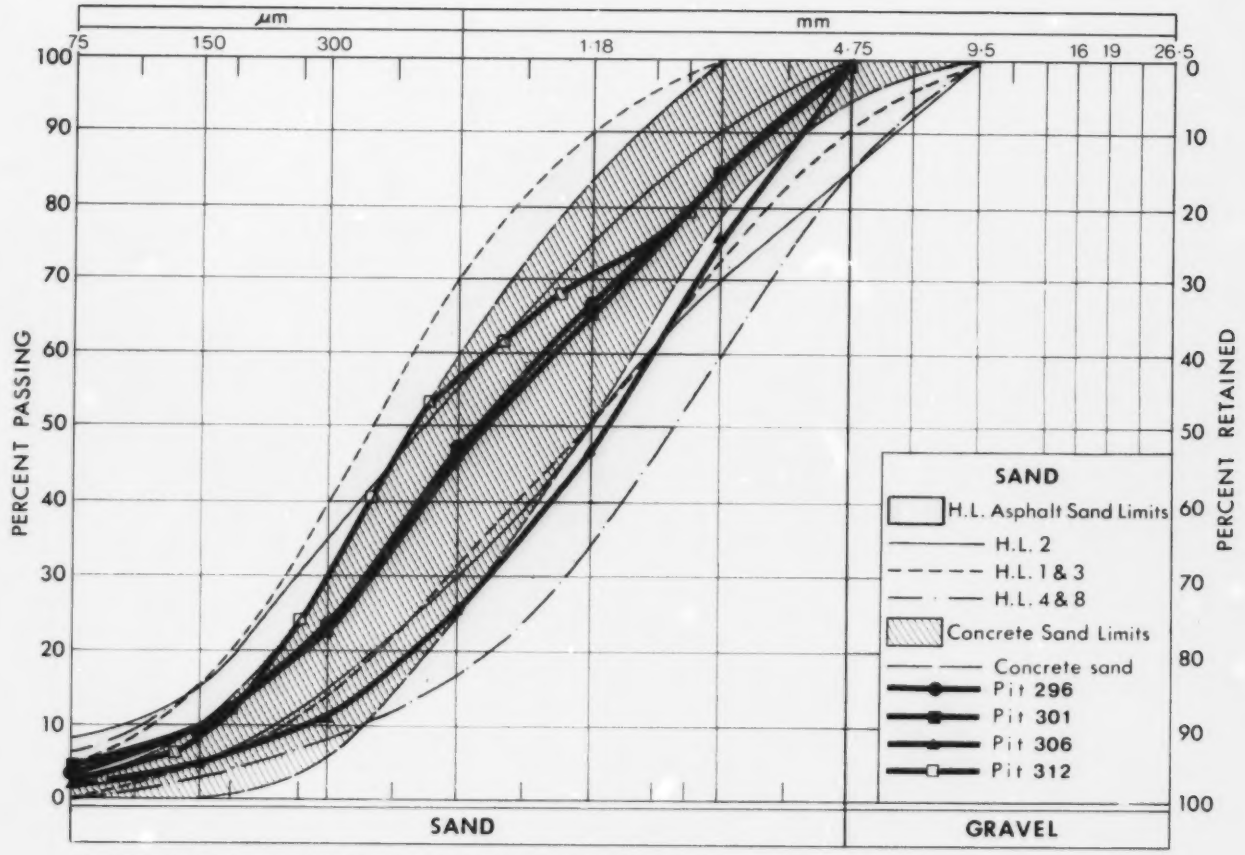


FIGURE 12b: AGGREGATE GRADING CURVES, TORY HILL - CARDIFF MAP AREA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

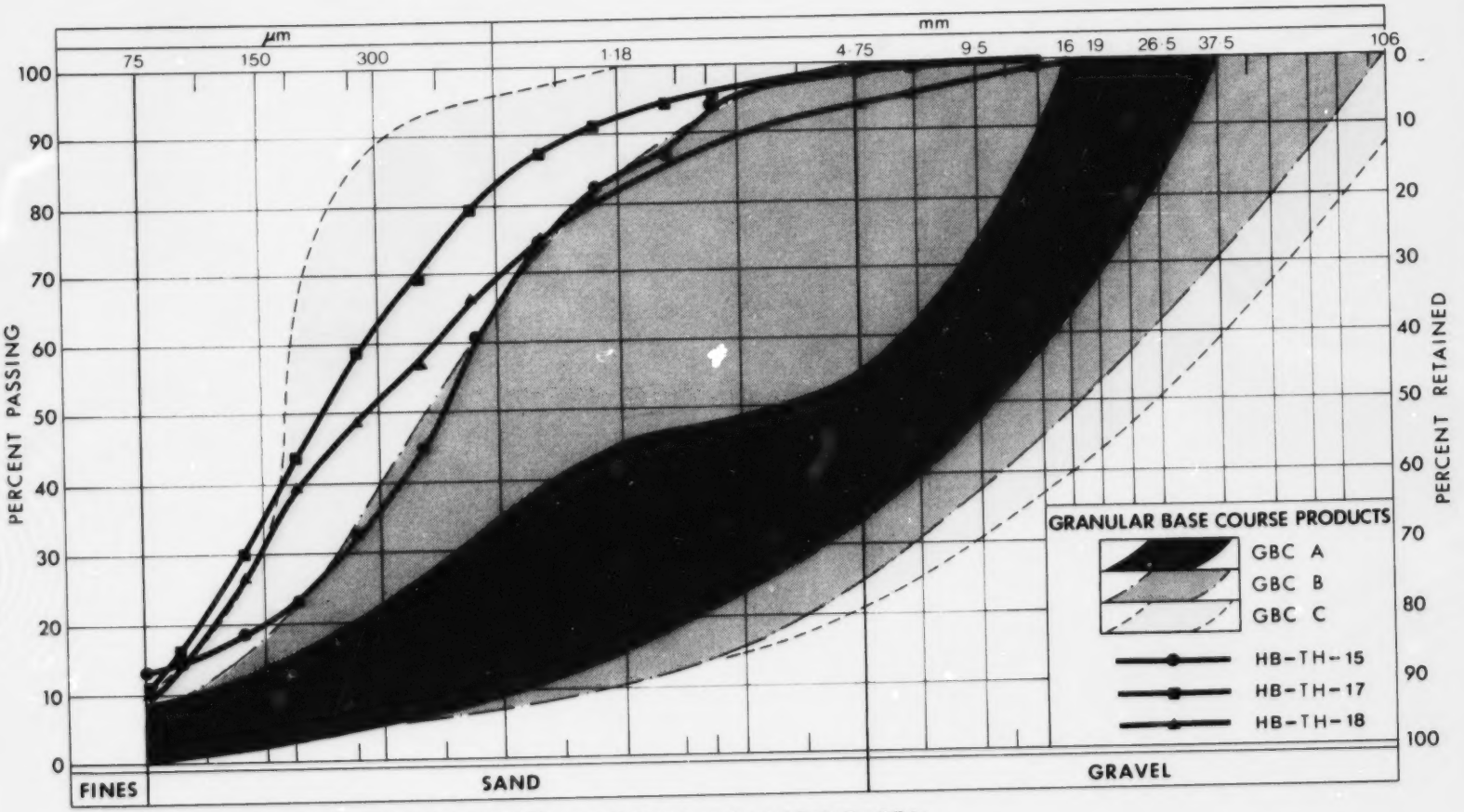


FIGURE 13a: AGGREGATE GRADING CURVES, TORY HILL - CARDIFF MAP AREA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

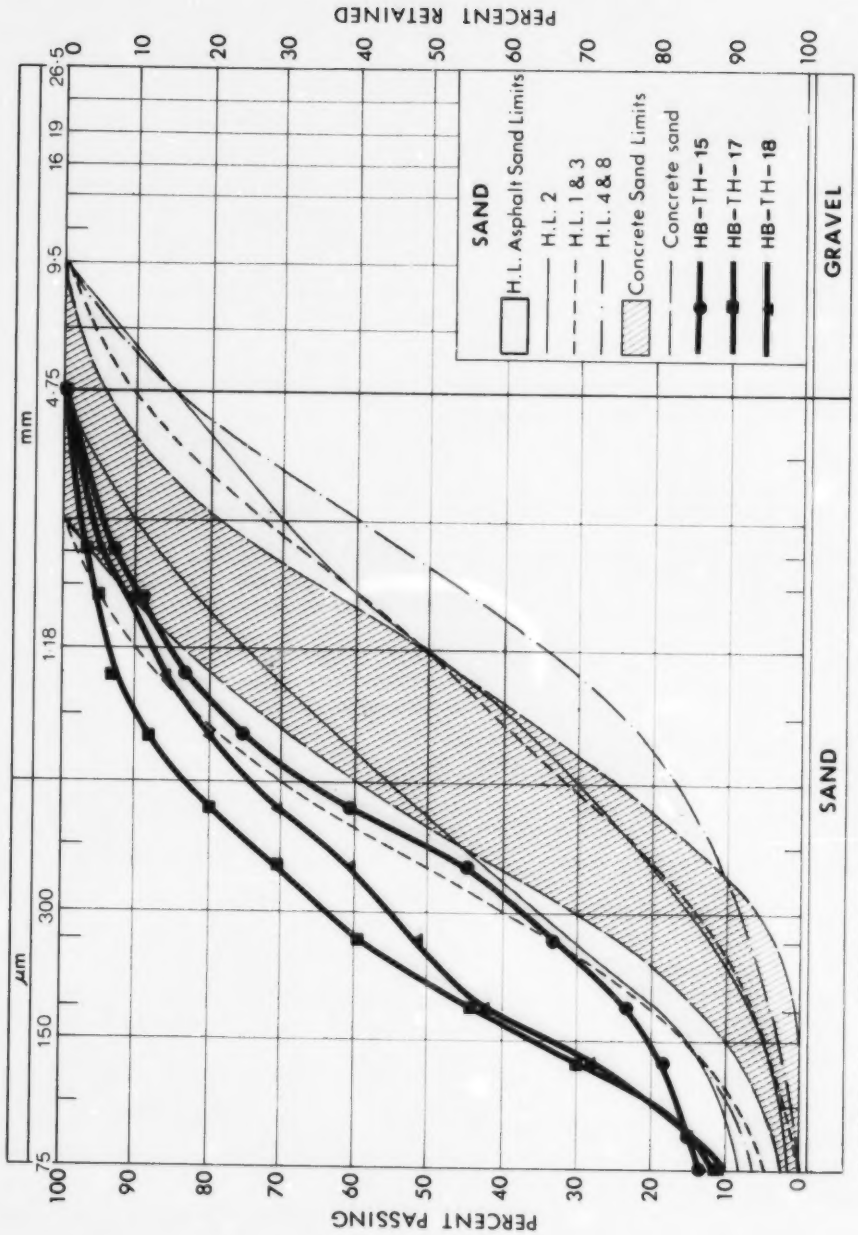


FIGURE 13b: AGGREGATE GRADING CURVES, TORY HILL - CARDIFF MAP AREA.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

References

Armstrong, H.S.
1970: Monmouth Township, Haliburton County; Ontario Department of Mines, Map 2174, scale 1:31 680.

Armstrong, H.S. and Gittins, J.
1968: Geology of Glamorgan and Monmouth Townships, Haliburton County; Ontario Department of Mines, Geological Branch, Open File Report 5021, 210p., 17 figures, 40 tables, and maps P.59 and P.60 in back pocket, scale 1:31 680.
1970: Glamorgan Township, Haliburton County; Ontario Department of Mines, Map 2173, scale 1:31 680.

Association of Professional Engineers of Ontario
1976: Performance Standards for Professional Engineers Advising on and Reporting on Oil, Gas and Mineral Properties; Association of Professional Engineers of Ontario, 11p.

Bright, E.G.
1987a: Geology of the Eels Lake Area, County of Peterborough; Ontario Geological Survey, Open File Report 5604, 190p., 8 figures, 20 tables, 12 photos, and Map P.2205 (revised) in back pocket, scale 1:50 000.
1987b: Precambrian Geology of the Centre Lake Area, Haliburton and Hastings Counties; Ontario Geological Survey, Open File Report 5658, 186p., 2 figures, 2 tables, and Maps P.2597 and p.2598 in back pocket. Scale 1:15 840.

Chapman, L.J., and Putnam, D.F.
1984: The Physiography of Southern Ontario, Third Edition; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map P.2715, scale 1:600 000.

Culshaw, N.G.
1986: Geology of the Drag Lake Area, Haliburton County; Ontario Geological Survey, Open File Report 5594, 79p., 7 figures, 4 plates, 7 tables, and 1 map in back pocket, scale 1 inch to 1/4 mile.

Culshaw, N.G., Davidson, A. and Nadeau L.
1983: Structural Subdivisions of the Grenville Province in the Parry Sound - Algonquin Region, Ontario; p.243-252 in Current Research, Part B, Geological Survey of Canada, Paper 83-1B, 456p.

Davidson, A., Britton, J.M., Bell, K. and Blenkinsop, J.
1979: Regional Synthesis of the Grenville Province of Ontario and Western Quebec; p.153-172 in Current Research, Part B, Geological Survey of Canada, Paper 79-1B, 420p.

Davidson, A., and Morgan, W.C.
1981: Preliminary Notes on the Geology East of Georgian Bay, Grenville Structural Province, Ontario; p.291-298 in Current Research, Part A, Geological Survey of Canada, Paper 81-1A, 404p.

Easton, R.M.
1986: Geology of the Digby-Lutterworth Area, Haliburton and Victoria Counties; Ontario Geological Survey, Open File Report 5601, 270p., 27 figures, 16 tables, 16 photos, and Maps P.2951 and P.2952 in back pocket, scale 1:15 840.
1987a: Geology of the Howland Area, Haliburton, Peterborough and Victoria Counties; Ontario Geological Survey, Open File Report 5639, 188p, 19 figures, 13 tables, 15 photographs, and Map P.2699 in back pocket, scale 1:15 840.
1987b: Geology of the Lochlin Area, County of Haliburton; Ontario Geological Survey, Open File Report 5678, 251p., 27 figures, 15 tables, 14 photos, 5 appendices, and Map P.3071 in back pocket, scale 1:15 840.

Finamore, P.F., and Courtney, S.J.
1982: Quaternary Geology of the Coe Hill Area, Southern Ontario; Ontario Geological Survey, Map P.2536, Geological Series-Preliminary Map, scale 1:50 000. Geology 1980.

Ford, M.J., and Geddes, R.S.
1986: Quaternary Geology of the Algonquin Park Area; Ontario Geological Survey, Open File Report 5600, 87p., 14 figures, 10 photos, Appendix, and Maps P.2608, P.2609, P.2698, P.2703, P.2704, P.2705, and P.2706 in back pocket, scale 1:50 000.

Henderson, E.P.
1972: Quaternary Geology, Gooderham-Apsley Area, Ontario; p.163-164 in Report of Activities, Part A: April to October 1971, Geological Survey of Canada, Paper 72-1A, 243p.
1973: Quaternary Geology, Haliburton-Burleigh Falls Area, Ontario; p.200-202 in Report of Activities, Part A: April to October 1972, Geological Survey of Canada, Paper 73-1A, 297p.

Hewitt, D.F.
1964: The Limestone Industries of Ontario, 1958-1963; Ontario Department of Mines, Industrial Mineral Report No. 13, 77p.

Kaszycki, C.A.
1985: History of Glacial Lake Algonquin in the Haliburton Region, South Central Ontario; p.109-123 in Quaternary Evolution of the Great Lakes, edited by P.F. Karrow and P.E. Calkin, Geological Association of Canada, Special Paper 30, 258p.
1987: A Model for Glacial and Proglacial Sedimentation in the Shield Terrane of Southern Ontario; Canadian Journal of Earth Sciences, Volume 24, November 12, pp.2373-2391.
In Prep: Quaternary Geology of the Gooderham (31 D/16), Haliburton (31 E/2), Minden (31 D/15) and Wilberforce (31 E/1) Map Sheets; Geological Survey of Canada, Maps in preparation.

Lumbers, S.B.
1979: Ontario Geological Map, Southern Sheet; Ontario Geological Survey, Map 2392, scale 1:1,013,760.

Marmont, C., and Johnston, M.
1987: Mineral Deposits Studies in the Huntsville-Parry Sound- Powassan Area –A Progress Report; Ontario Geological Survey, Open File Report 5647, 222p., 9 tables, 30 figures, 12 photos, and 5 charts in back pocket.

Martin, Wendy
1983: Industrial Minerals of the Algonquin Region; Ontario Geological Survey, Open File Report 5425, 316p., accompanied by Maps P.2562, P.2563, P.2564, P2565, P.2566, P.2567, scale 1:15,840.

Mollard, D.G.
1980: Southern Ontario Engineering Geology Terrain Study Maps: Bancroft and Haliburton; Ontario Geological Survey, Open File Report 5317, 2p., 4 maps, scale 1:100 000.

Ontario Interministerial Committee on National Standards and Specifications (Metric Committee)
1975: Metric Practice Guide; 67p.

Ontario Ministry of Intergovernmental Affairs
1981: Municipal Directory 1981; Queen's Printer for Ontario, 191p.

Ontario Ministry of Municipal Affairs
1988: Municipal Directory 1988; Queen's Printer for Ontario, 347p.

Ontario Ministry of Northern Development and Mines
1988: 1987 Ontario Mineral score; Ontario Ministry of Northern Development and Mines, Mineral Development and Lands Branch, 194p.

Robertson, J.A.
1975: Mineral Deposit Studies, Mineral Potential Evaluation, and Regional Planning in Ontario; Ontario Division of Mines, Miscellaneous Paper 61, 42p.

Rogers, C.A.
1985: Alkali-Aggregate Reactions, Concrete Aggregate Testing and Problem Aggregate in Ontario, A Review, Fifth Revised Edition; Ontario Ministry of Transportation and Communications, Engineering Materials Office, Soils and Aggregates Section, Report EM-31, 44p.

Rust, Brian R. and Romanelli, Richard
1975: Late Quaternary Subaqueous Outwash Deposits Near Ottawa, Canada; P.177-192 in Glaciofluvial and Glaciolacustrine Sedimentation, edited by Alan V. Jopling and Barrie C. McDonald, Society of Economic Paleontologists and Mineralogists, Special Publication No. 23, 320p.

Satterly, J.
1943: Mineral Occurrences in the Haliburton Area; Ontario Department of Mines, Fifty-Second Annual Report, Volume 52, Part 2, 106p., Accompanied by Map 52a, scale 1:126 720.

Van Luit, J., Etches, J., Keevil, R.
1984: Aggregate Resources Assessment of the Leslie M. Frost Natural Resources Centre; Ministry of Natural Resources, unpublished report.

Wynne-Edwards, H.R.
1972: The Grenville Province; p.263-334 in Variations in Tectonic Styles in Canada, edited by R.A. Price and R.J.W. Douglas, The Geological Association of Canada, Special Paper 11, 688p.

Appendix A — Suggested Additional Reading

Antevs, E.
1928: The Last Glaciation, with Special Reference to the Ice Retreat in Northeastern North America; American Geography Society, Res. Ser. No. 17, 292 p.

Banerjee, I. and McDonald, B.C.
1975: Nature of Esker Sedimentation; in Glaciofluvial and Glaciolacustrine Sedimentation, ed. Jopling, A.V. and McDonald, B.C., Society of Economic Paleontologists and Mineralogists, Special Paper No. 23, 22 p.

Bates, Robert L. and Jackson, Julia A.
1987: Glossary of Geology, Third Edition; American Geological Institute, Alexandria, Virginia, U.S.A., 788p.

Bauer, A.M.
1970: A Guide to Site Development and Rehabilitation of Pits and Quarries; Ontario Department of Mines, Industrial Mineral Report 33, 62 p.

Boissonneau, A.N.
1966: Glacial History of Northeastern Ontario, 1 - The Cochrane-Hearst Area; Canadian Journal of Earth Sciences, Volume 3, Number 5, pp. 559-578.

Cowan, W.R.
1977: Toward the Inventory of Ontario's Mineral Aggregates; Ontario Geological Survey, Miscellaneous Paper 73, 19 p.

Fairbridge, R.W. (ed.)
1968: The Encyclopedia of Geomorphology; Encyclopedia of Earth Sciences, Vol. III, Reinhold Book Corp., N.Y., 1295 p.

Flint, R.F.
1971: Glacial and Quaternary Geology; John Wiley and Sons Inc., 892 p.

Hewitt, D.F. and Vos, M.A.
1970: Urbanization and Rehabilitation of Pits and Quarries; Ontario Department of Mines, Industrial Mineral Report 34, 21 p.

Lowe, S.B.
1980: Trees and Shrubs for the Improvement and Rehabilitation of Pits and Quarries in Ontario; Ontario Ministry of Natural Resources, 71 p.

McLellan, A.G., Yundt, S.E. and Dorfman, M.L.
1979: Abandoned Pits and Quarries in Ontario; Ontario Geological Survey, Miscellaneous Paper 79, 36 p.

Michalski, Micheal F.P., Gregory, Daniel RI, and Usher, Anthony J.
1987: Rehabilitation of Pits and Quarries for Fish and Wildlife; Ontario Ministry of Natural Resourcess, Land Management Branch, 59p.

Ontario
1980: The Mining Act; Revised Statutes of Ontario, 1980, Chapter 268, Queen's Printer for Ontario.

Ontario Mineral Aggregate Working Party
1977: A Policy for Mineral Aggregate Resource Management in Ontario; Ontario Ministry of Natural Resources, 232 p.

Ontario Ministry of Natural Resources
1975: Vegetation for the Rehabilitaion of Pits and Quarries; Forest Management Branch, Division of Forests, 38 p.

Rogers, C.A.
1985: Evaluation of the Potential for Expansion and Cracking of Concrete due to the Alkali-Carbonate Reaction; Cement, Concrete and Aggregates, CCAGDP, Vol. 8, No. 1, Summer, pp. 13-23

Appendix B — Glossary

ABRASION RESISTANCE: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

AGGREGATE ABRASION VALUE: This test directly measures the resistance of aggregate to abrasin with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high quality asphalt surface course uses, values of less than 6 are desirable.

ALKALI-AGGREGATE REACTION: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BENEFICIATION: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing, or classification. Heavy media separation, jigging, or application of special crushers (e.g. "cage mill") are usually considered processes of beneficiation.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

BULK RELATIVE DENSITY: An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

CAMBRIAN: The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

CLAST: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in Ontario.

GNEISS: A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent of its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANITE: A coarse-grained light coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, horneblende or both.

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

LOS ANGELES ABRASION AND IMPACT TEST: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indicate potential problems for concrete and asphalt coarse aggregate.

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. In Ontario the test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE: An epoch of the recent geological past incuding the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POLISHED STONE VALUE: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the PSV, the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, while values greater than 55 indicate excellent frictional properties.

POSSIBLE RESOURCE: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SOUNDNESS: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT) These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K) Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E) Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC) This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW) Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Subaqueous Fan (SF) Subaqueous fans are formed within or near the mouths of meltwater conduits when sediment-laden meltwaters are discharged into a standing body of water. The geometry of the resulting deposit is fan- or lobe-shaped. Several of these lobes may be joined together to form a larger, continuous sedimentary body. Internally, subaqueous fans consist of stratified sands and gravels which may exhibit wide variations in grain size distribution. As these features were deposited under glacial lake waters, silt and clay which settled out of these lakes may be associated in varying amounts with these deposits. The variability of the sediments and presence of fines are the main extractive problems associated with these deposits.

Alluvium (AL) Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB) These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD) These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP) The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM) These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD) Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probabiltiy of locating crushable aggregate in windblown deposits is very low.

Appendix D — Aggregate Quality Testing

Four types of aggregate quality tests have been performed on selected samples from the project area. A description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the four major tests listed in this appendix can be used to determine the suitability of an aggregate. The above four types of tests were performed by the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation.

Absorption Capacity Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate. This test is conducted in conjunction with the determination of the sample's relative density.

Los Angeles Abrasion and Impact Test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performence for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indicate potential problems for concrete and asphalt coarse aggregate.

Petrographic Examination Individual aggregate particles in a sample are divided into categories good, fair, poor, and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

TABLE D1. SELECTED QUALITY REQUIREMENTS FOR MAJOR AGGREGATE PRODUCTS

	TYPE OF TEST				
	COARSE AGGREGATE				FINE AGGREGATE
TYPE OF MATERIAL	Petrographic Number Maximum	Magnesium Sulphate Soundness Maximum % Loss	Absorption Maximum %	Los Angeles Abrasion Maximum % Loss	Magnesium Sulphate Soundness Maximum % Loss
Granular Base A	200	-	-	60	-
16 mm Crushed Type 'A'	160	-	-	35	-
16 mm Crushed Type 'B'	200	-	-	60	-
Granular Subbase B	250	-	-	-	-
Granular Subbase C	250	-	-	-	-
Granular Subbase D	-	-	-	-	-
Hot Mix - H.L. 1	100	5	1.0	15	16
Hot Mix - H.L. 2	-	-	-	-	20
Hot Mix - H.L. 3	135	12	1.75	35	16
Hot Mix - H.L. 4	160	12	2.0	35	20
Hot Mix - H.L. 8	160	15	2.0	35	20
Structural Concrete and Concrete Base	140	12	2.0	35	16
Pavement Concrete and Exposed Structure Deck	125	12	2.0	35	16

(Ministry of Transportation Forms 1002, 1003 and 1010)

Appendix E —Leslie M. Frost Natural Resources Centre Geophysics Data and Aggregate Grading Curves

In addition to the aggregate sampling and subsurface testing performed by the staff of the Aggregate Assessment Office during the 1986 field investigation, sampling and geophysical surveys had previously been carried out by the staff of the Leslie M. Frost Natural Resources Centre (L.M.F.N.R.C.), within the boundaries of the L.M.F.N.R.C. The symbols for and locations of these sample sites and geophysical traverse lines are noted on Map 1A. The results of the hammer seismic geophysical surveys are presented in Table E1. The staff of the L.M.F.N.R.C. collected and screened aggregate samples for grain size distribution. The results of their grain size analysis have been plotted on aggregate grading curves to indicate if the sampled material meets Ministry of Transportation specifications for granular base course products. These aggregate grading curves are presented in Figures E1 to E16.

TABLE E1. SUMMARY OF GEOPHYSICS DATA, LESLIE M. FROST NATURAL RESOURCES CENTRE.

Line Number: LF-GT-1
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data:
Number of Layers: 4
Layer Velocities: V_1= 800 ft/sec (244 m/sec)
V_2= 1779 ft/sec (542 m/sec)
V_3= 6064 ft/sec (1848 m/sec)
V_4= 20,000 ft/sec (6096 m/sec)
Layer Thickness: D_1= 2.5 ft (0.8 m)
D_2= 23.8 ft (7.3 m)
D_3= 54.8 ft (16.7 m)

Line Number: LF-GT-2
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data: Forward
Number of Layers: 3
Layer Velocities: V_1= 73.6 ft/sec (22 m/sec)
V_2= 1512 ft/sec (461 m/sec)
V_3= 8258 ft/sec (2517 m/sec)
Layer Thickness: D_1= 2.1 ft (0.6 m)
D_2= 29.4 ft (9 m)

Line Number: LF-GT-3
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data: Forward
Number of Layers: 3
Layer Velocities: V_1= 903 ft/sec (275 m/sec)
V_2= 1687 ft/sec (514 m/sec)
V_3= 4609 ft/sec (1405 m/sec)
Layer Thickness: D_1= 3.9 ft (1.2 m)
D_2= 12.9 ft (3.9 m)

Line Number: LF-GT-4
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1106 ft/sec (337 m/sec)
V_2= 4910 ft/sec (1494 m/sec)
Layer Thickness: D_1= 10.3 ft (3.1 m)

Line Number: LF-GT-5
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data:
Number of Layers: 4
Layer Velocities: V_1= 59 ft/sec (18 m/sec)
V_2= 1142 ft/sec (348 m/sec)
V_3= 2818 ft/sec (859 m/sec)
V_4= 144,000 ft/sec (43,891 m./sec)
Layer Thickness: D_1= 2.4 ft (0.7 m/sec)
D_2= 8.1 ft (2.5 m/sec)
D_3= 21.1 ft (6.4 m/sec)

Line Number: LF-GT-6
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data:
Number of Layers: 3
Layer Velocities: V_1= 828 ft/sec (252 m/sec)
V_2= 2333 ft/sec (711 m/sec)
V_3= 16,000 ft/sec (4877 m/sec)
Layer Thickness: D_1= 4.1 ft (1.2 m)
D_2= 16.5 ft (5 m)

Line Number: LF-GT-7
Method: Hammer Seismic (Nimbus ES-125)
Seismic Data:
Number of Layers: 3
Layer Velocities: V_1= 571 ft/sec (174 m/sec)
V_2= 1757 ft/sec (536 m/sec)
V_3= 26,200 ft/sec (7986 m/sec)
Layer Thickness: D_1= 1.4 ft (0.4 m/sec)
D_2= 32 ft (9.8 m/sec)

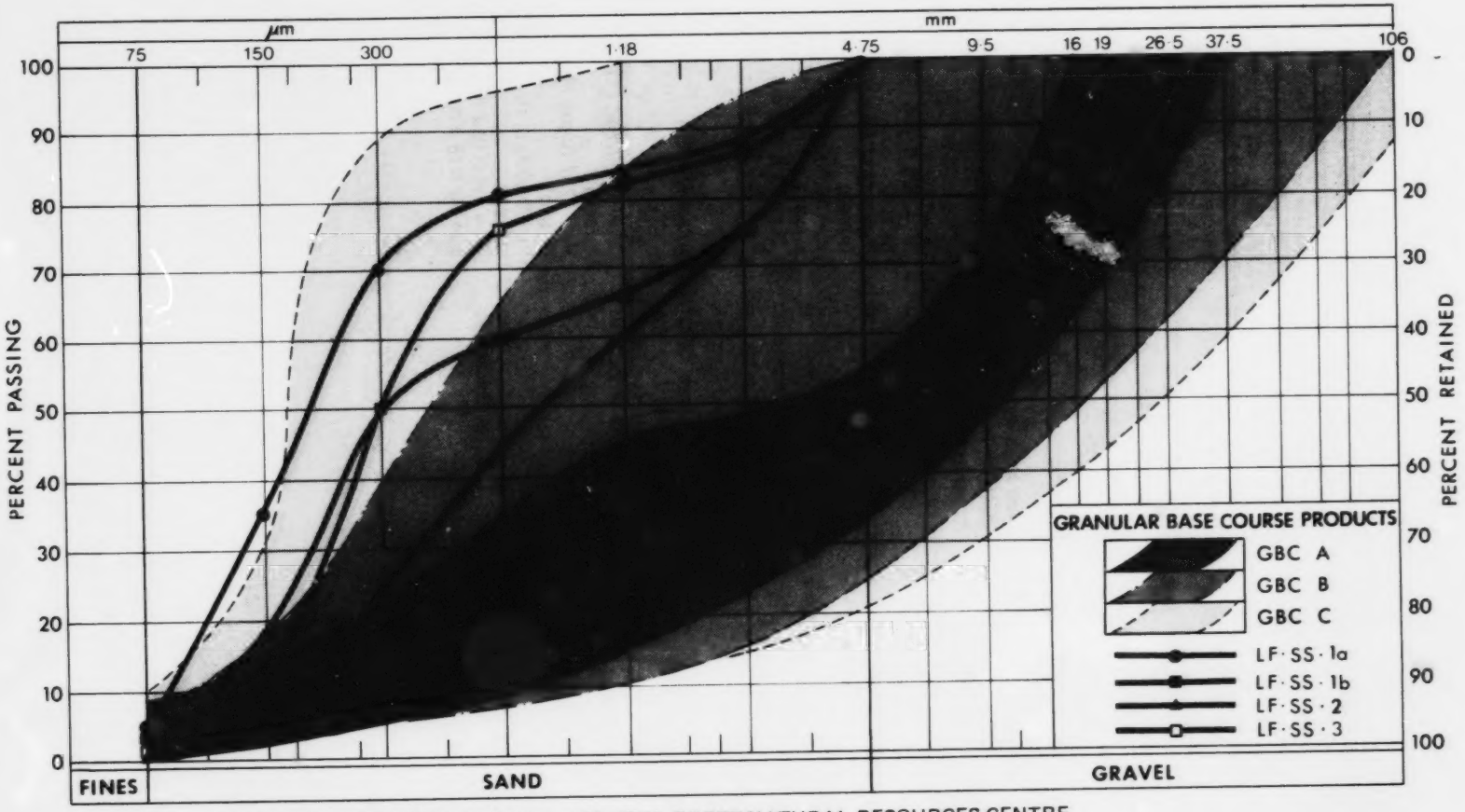


FIGURE E1: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

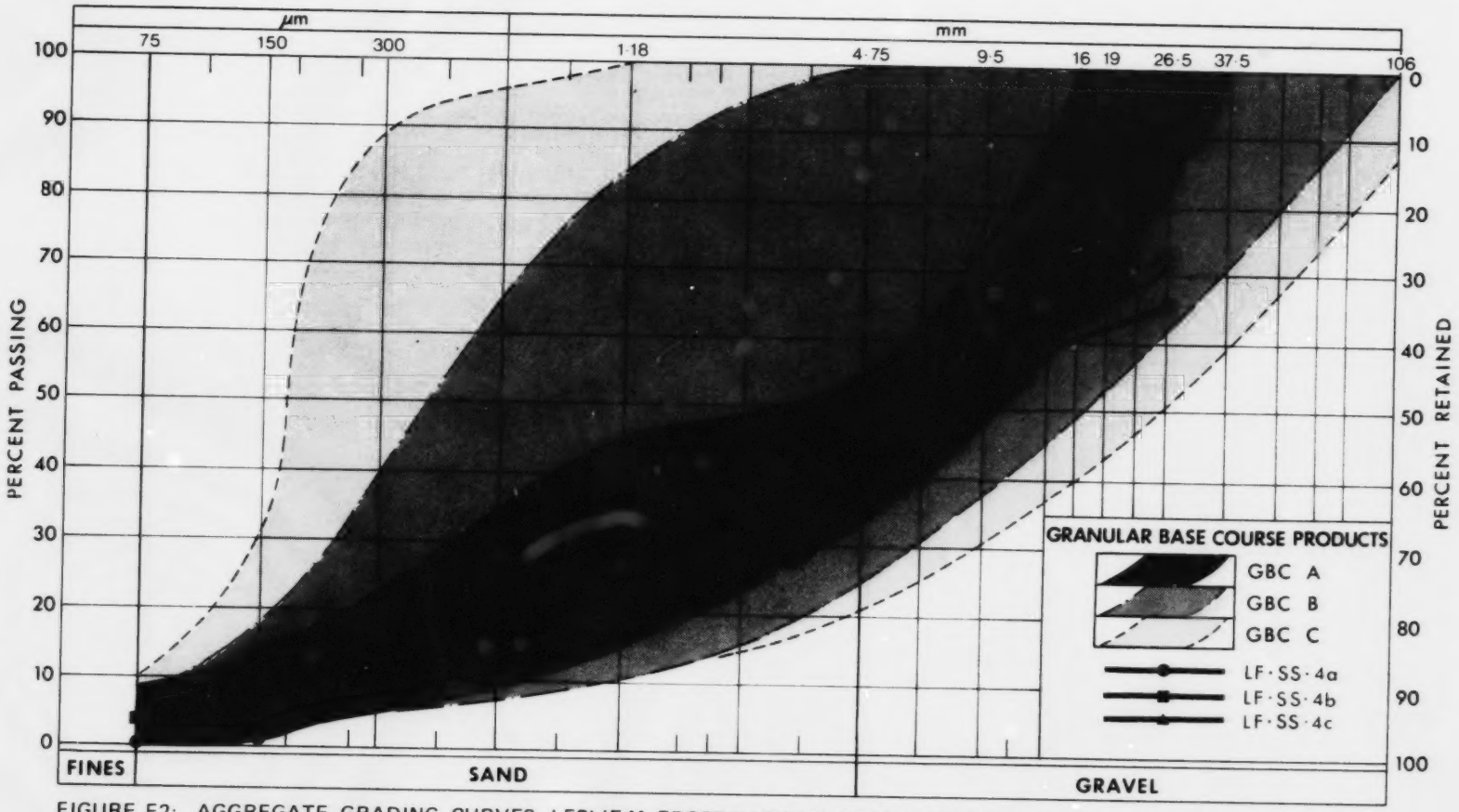


FIGURE E2: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

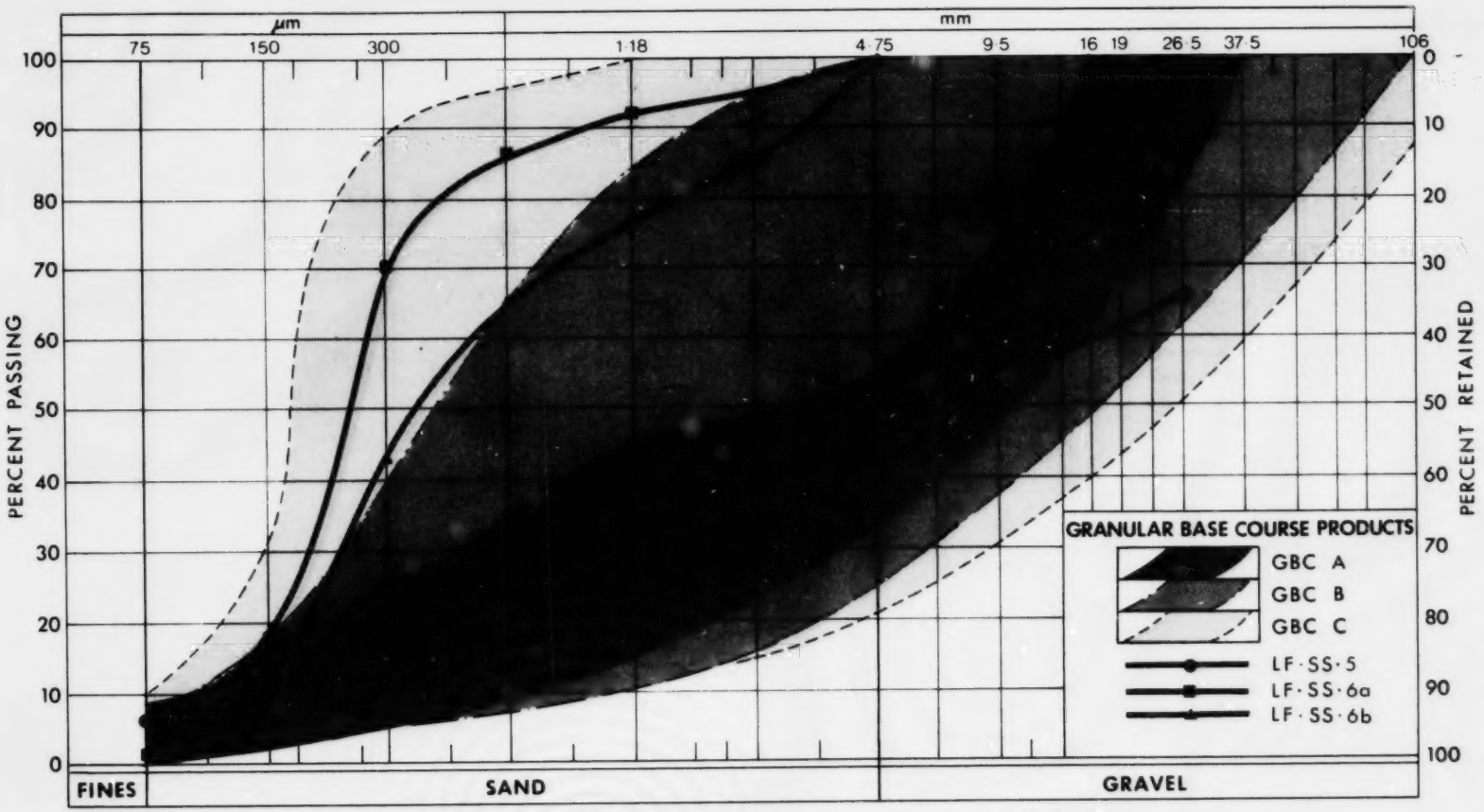


FIGURE E3: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

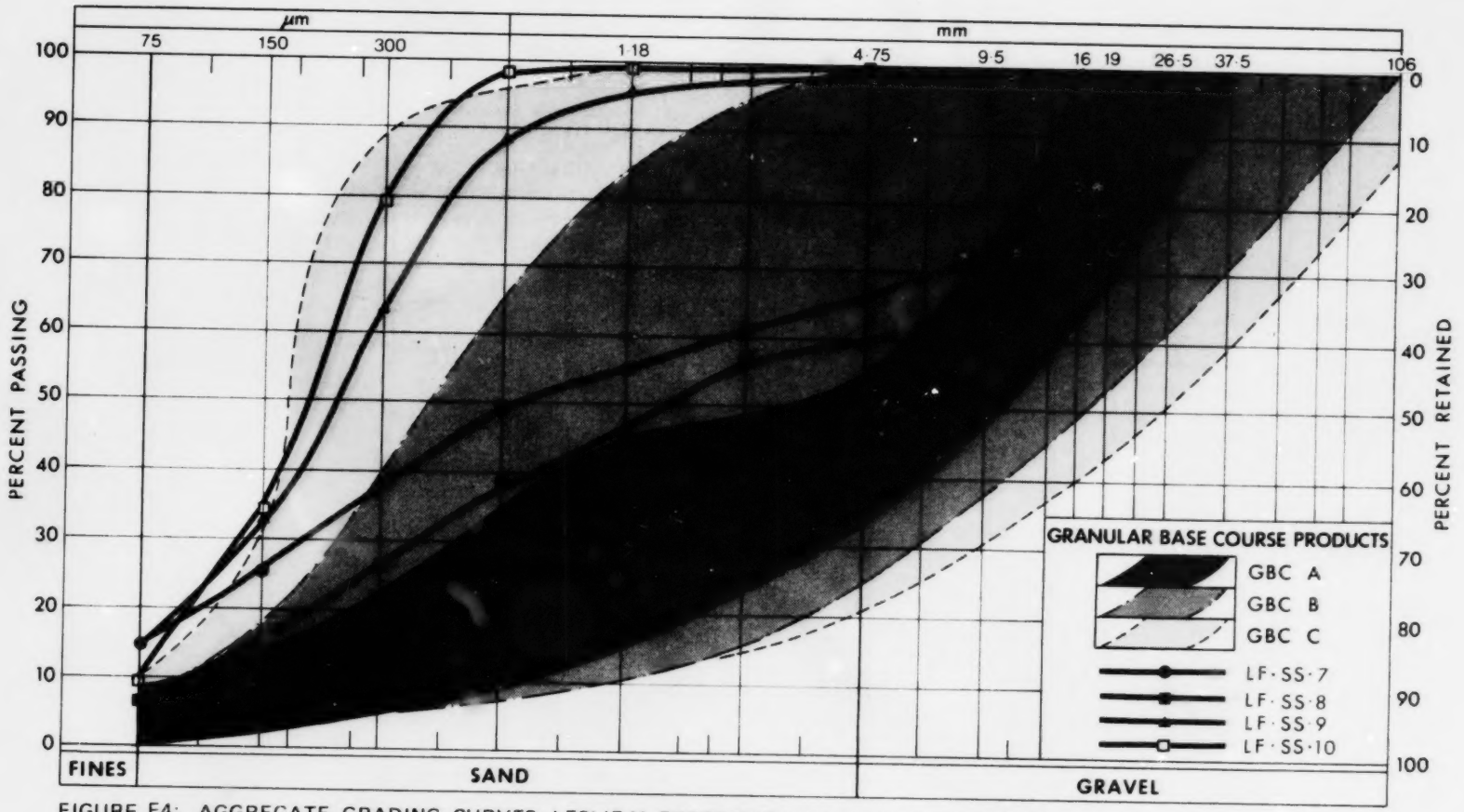


FIGURE E4: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

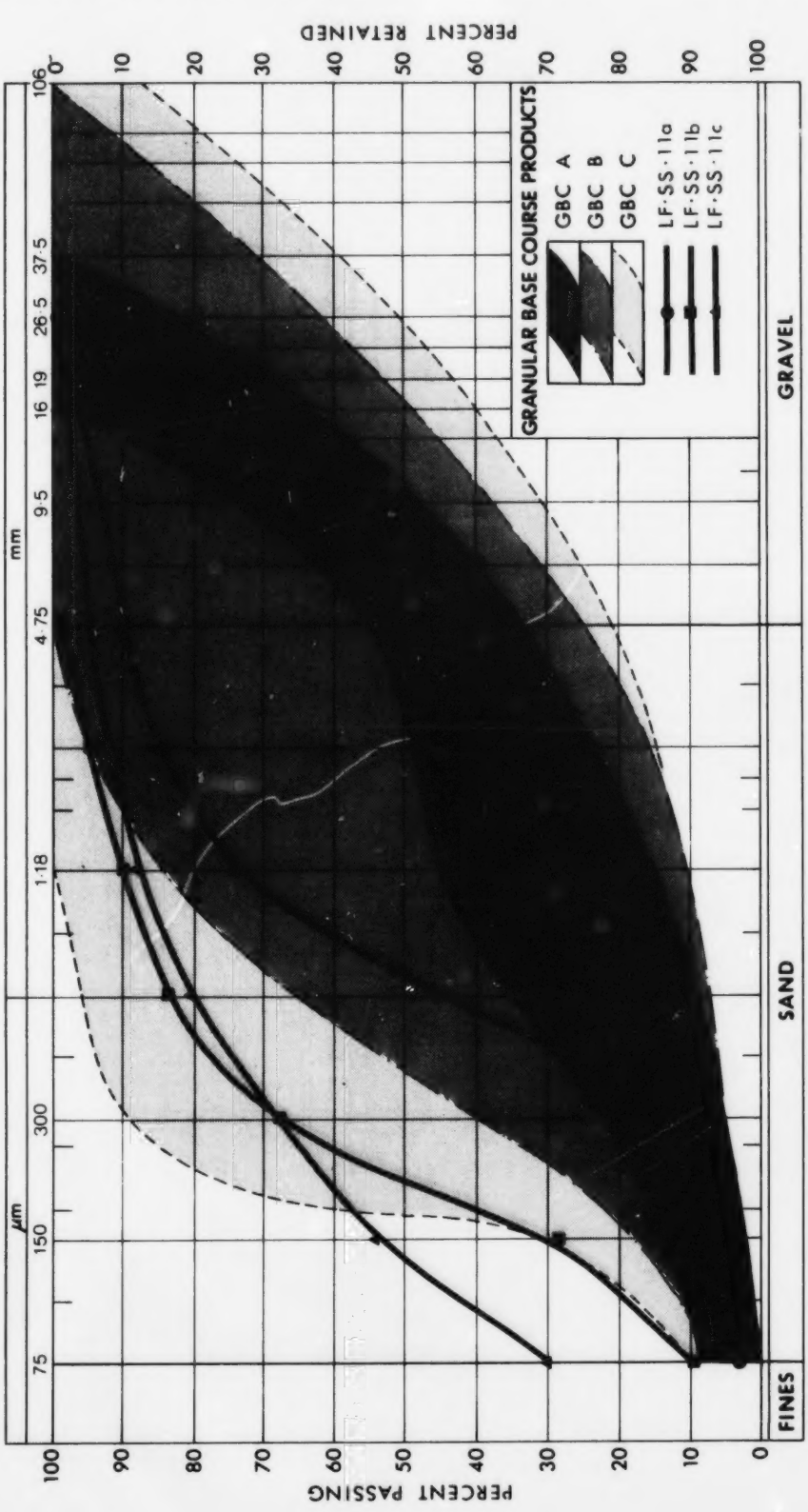


FIGURE E5: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

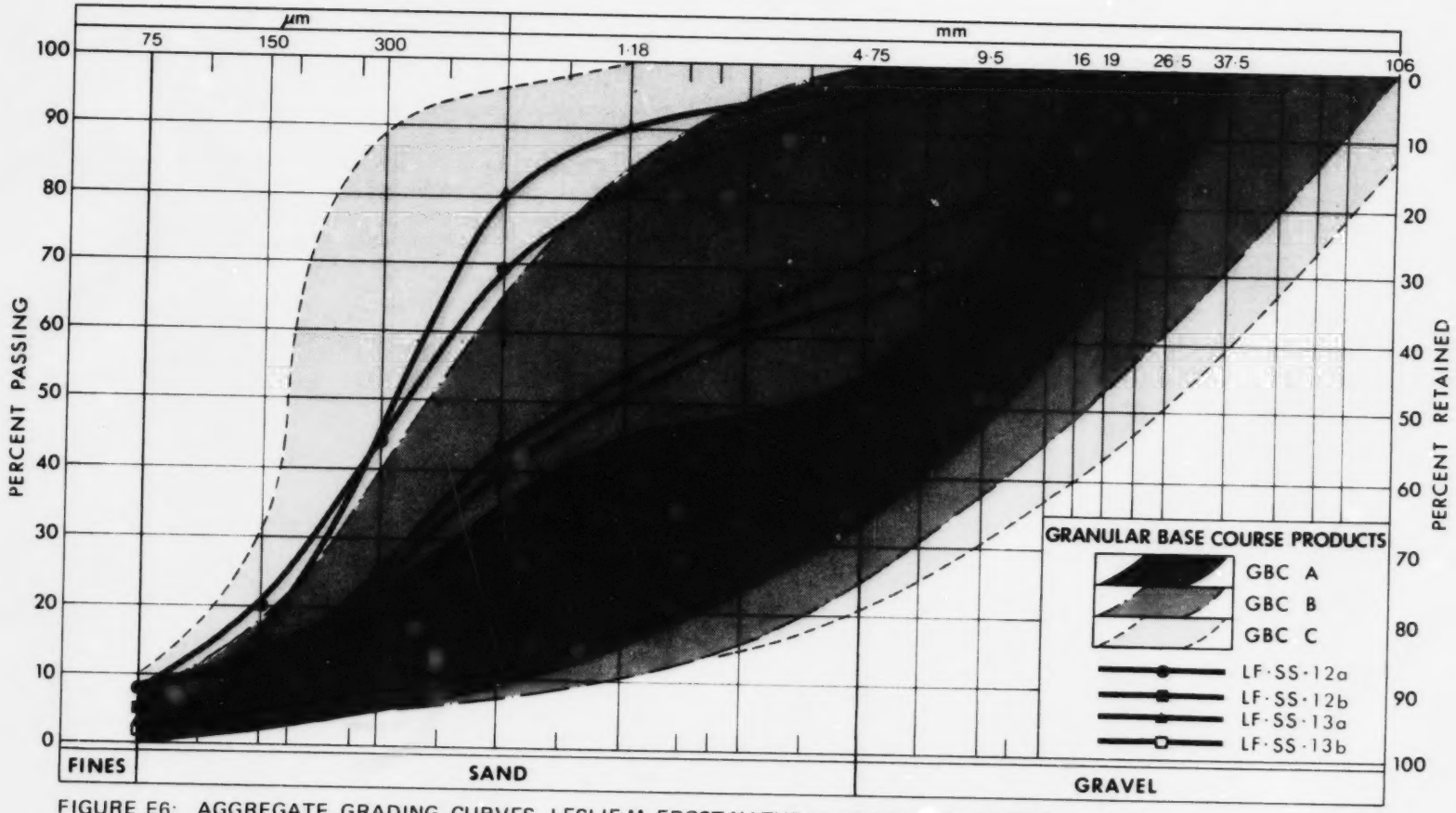


FIGURE E6: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

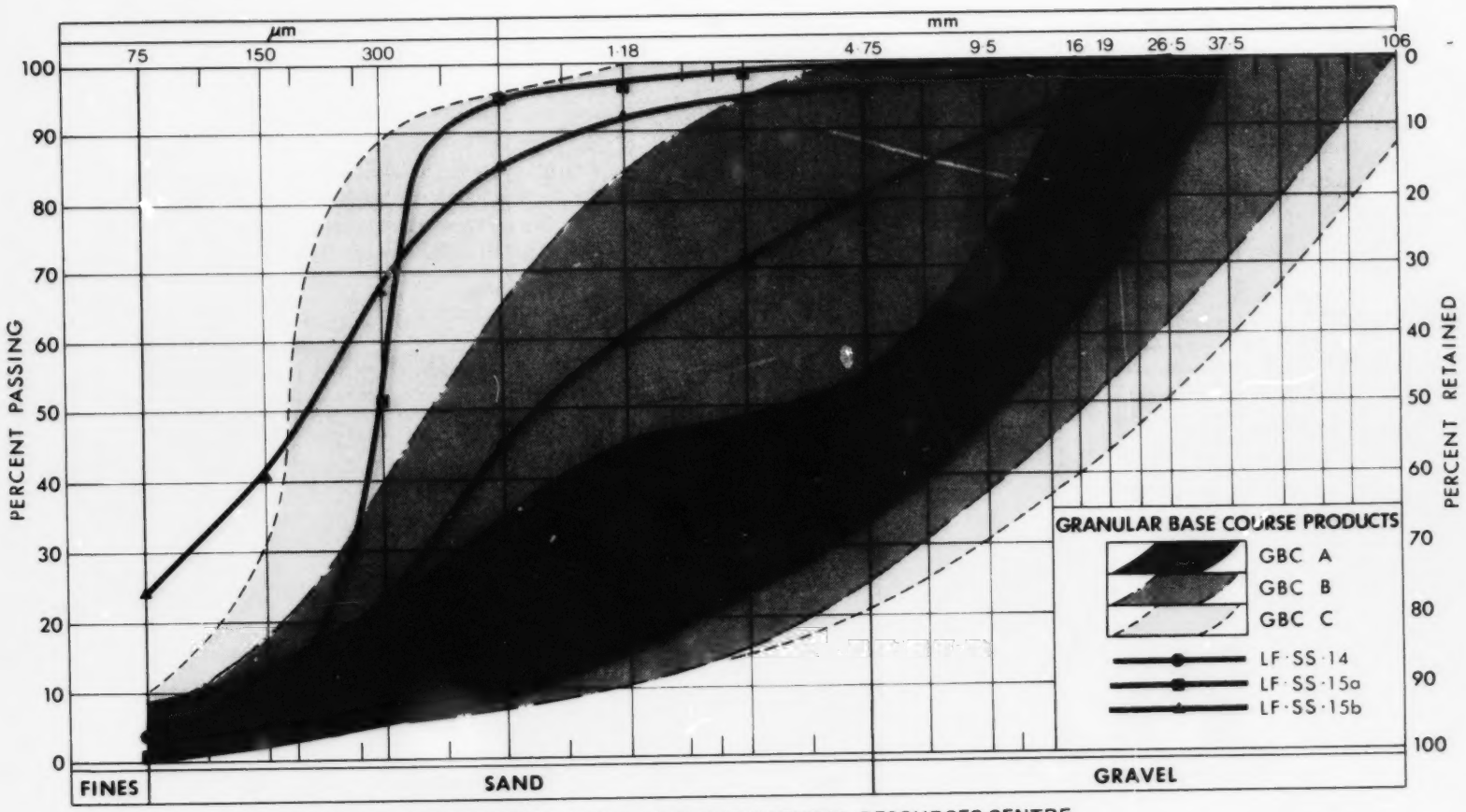


FIGURE E7: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

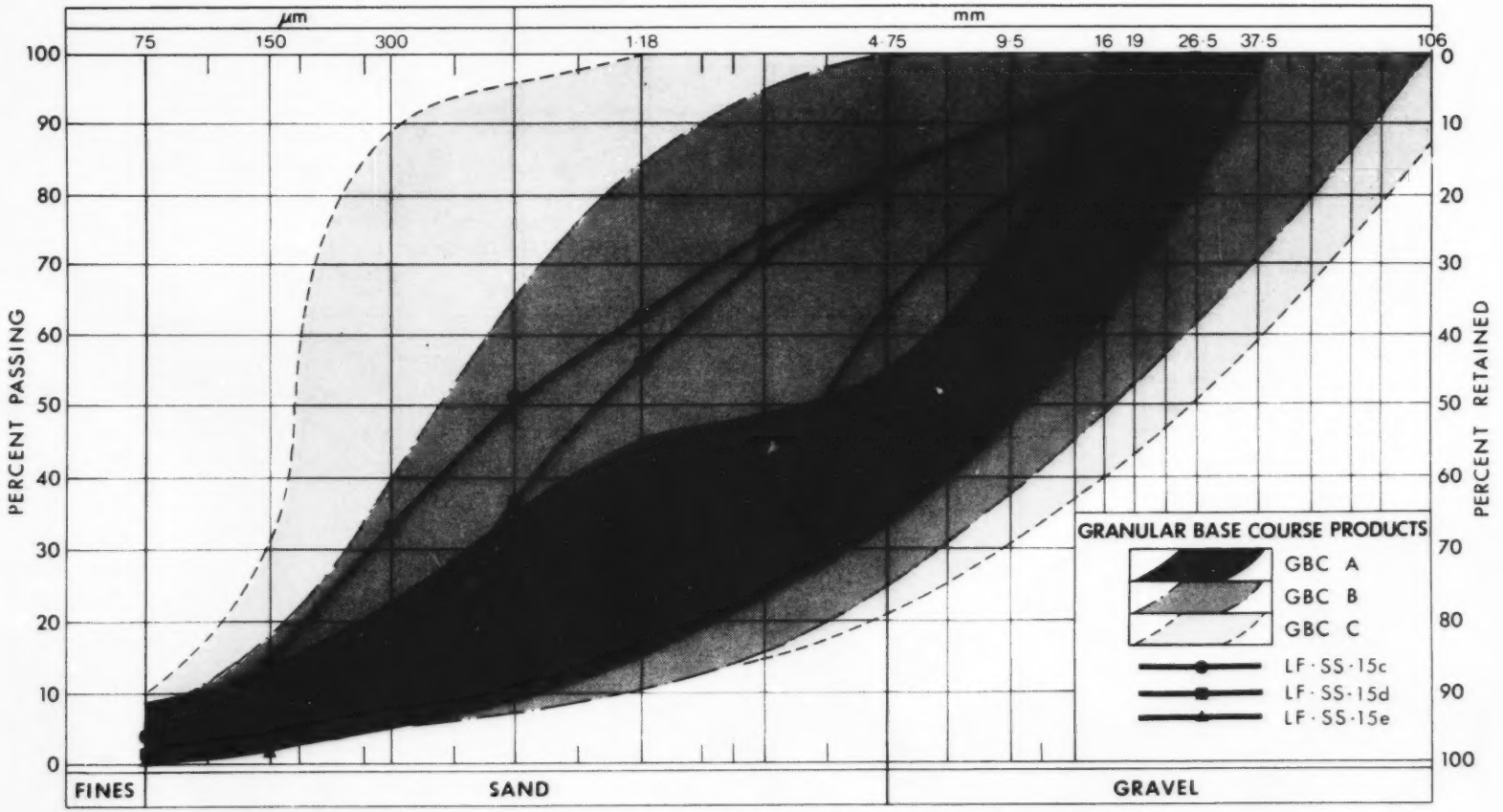


FIGURE E8: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

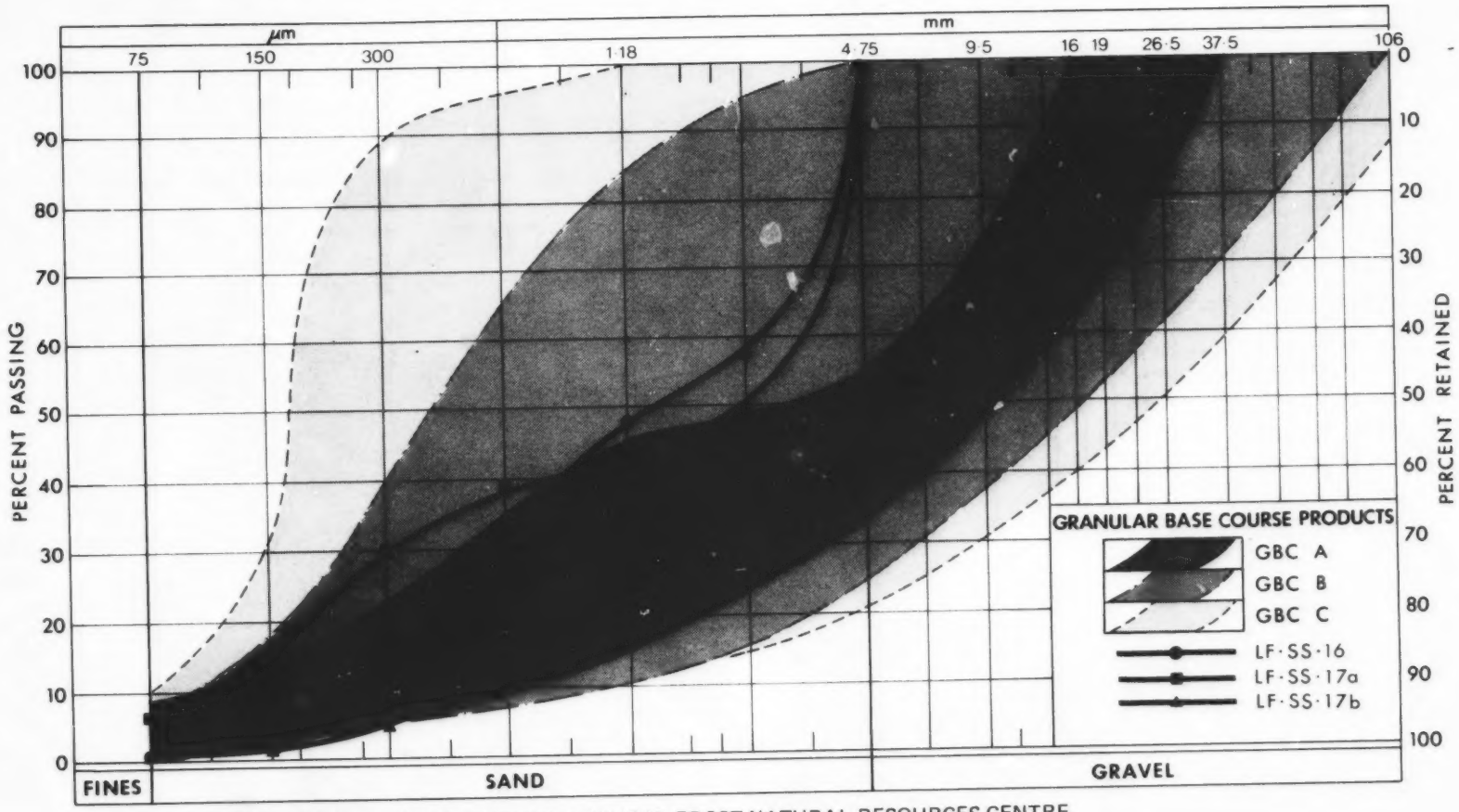


FIGURE E9: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

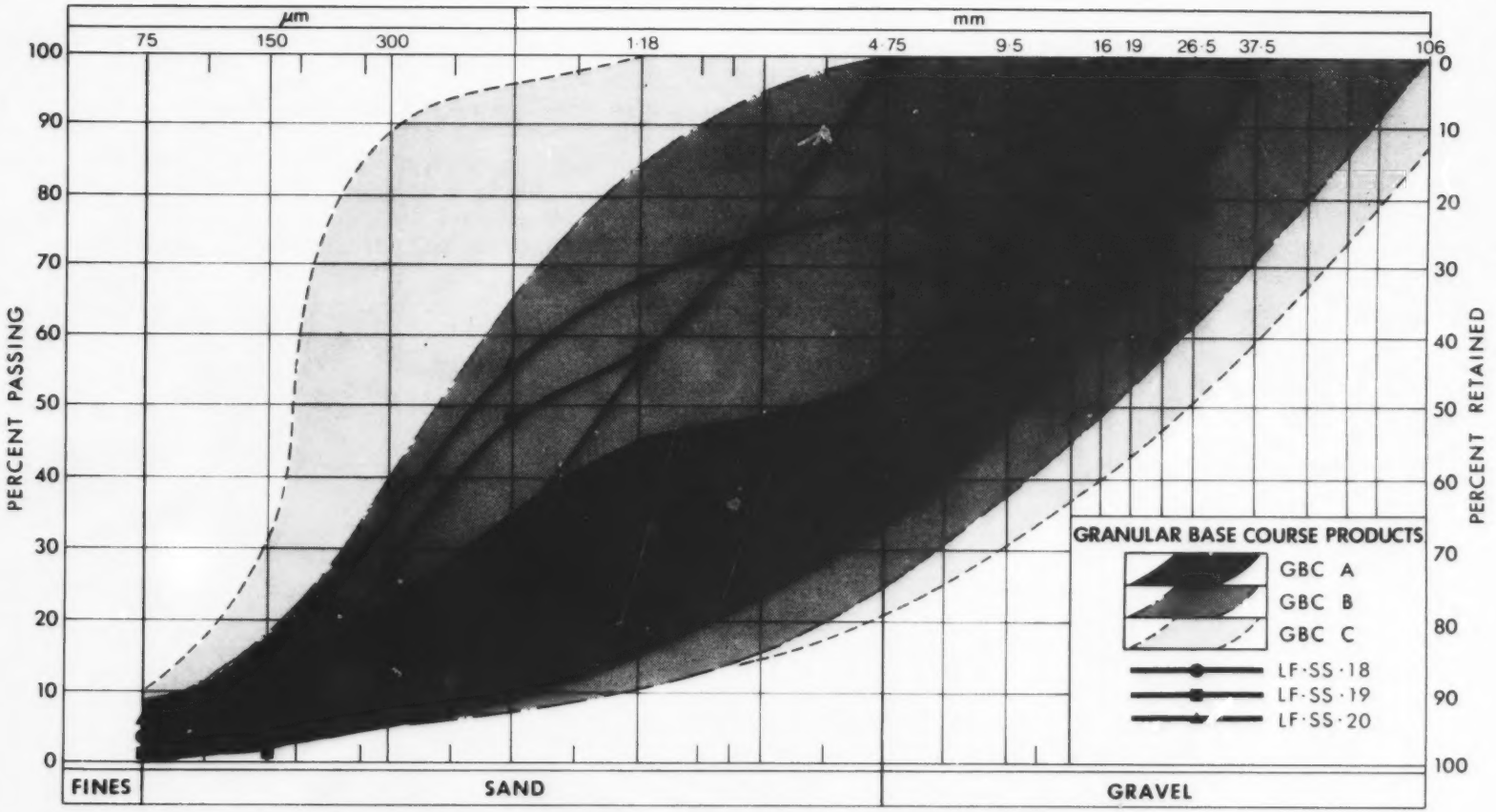


FIGURE E10: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

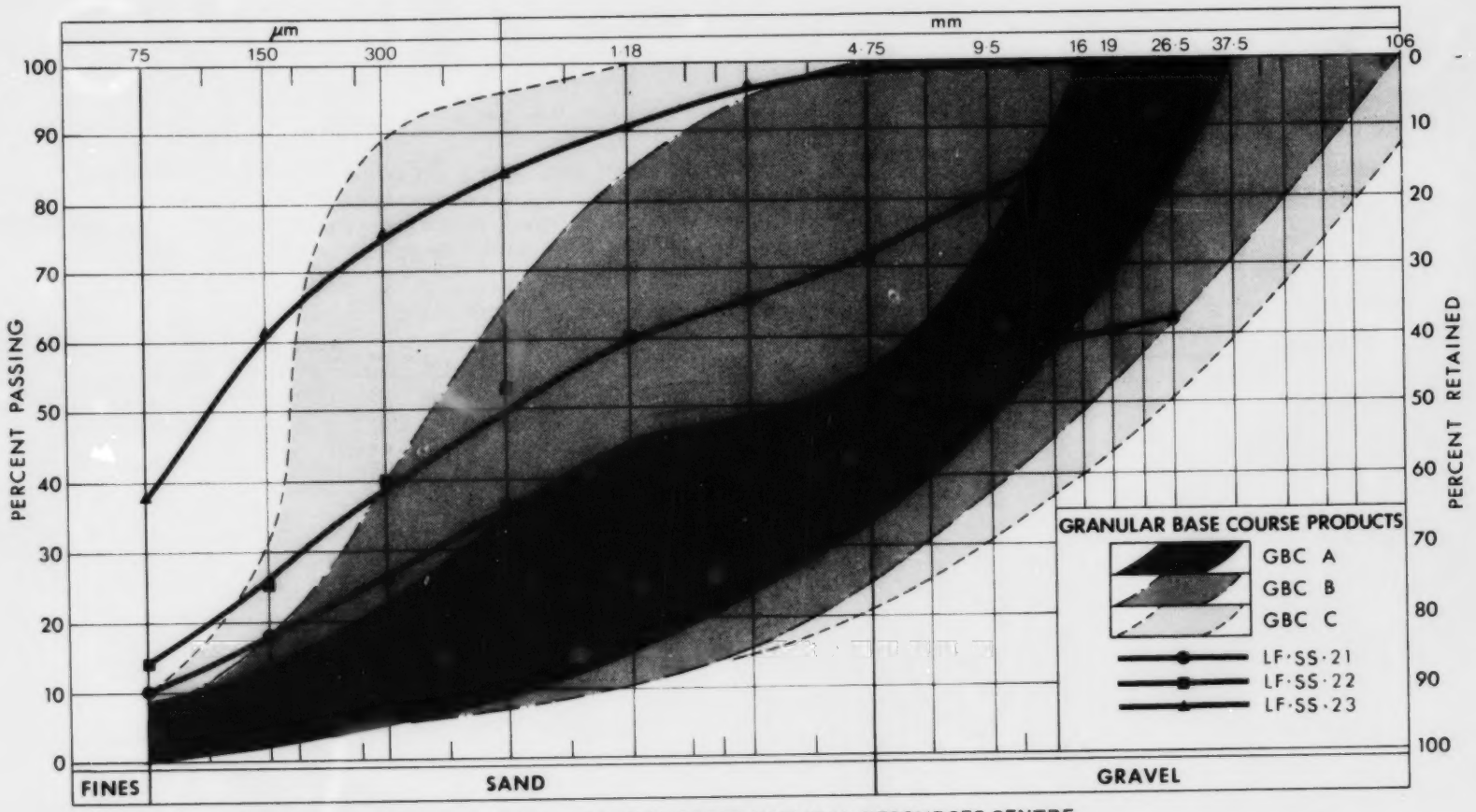


FIGURE E11: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

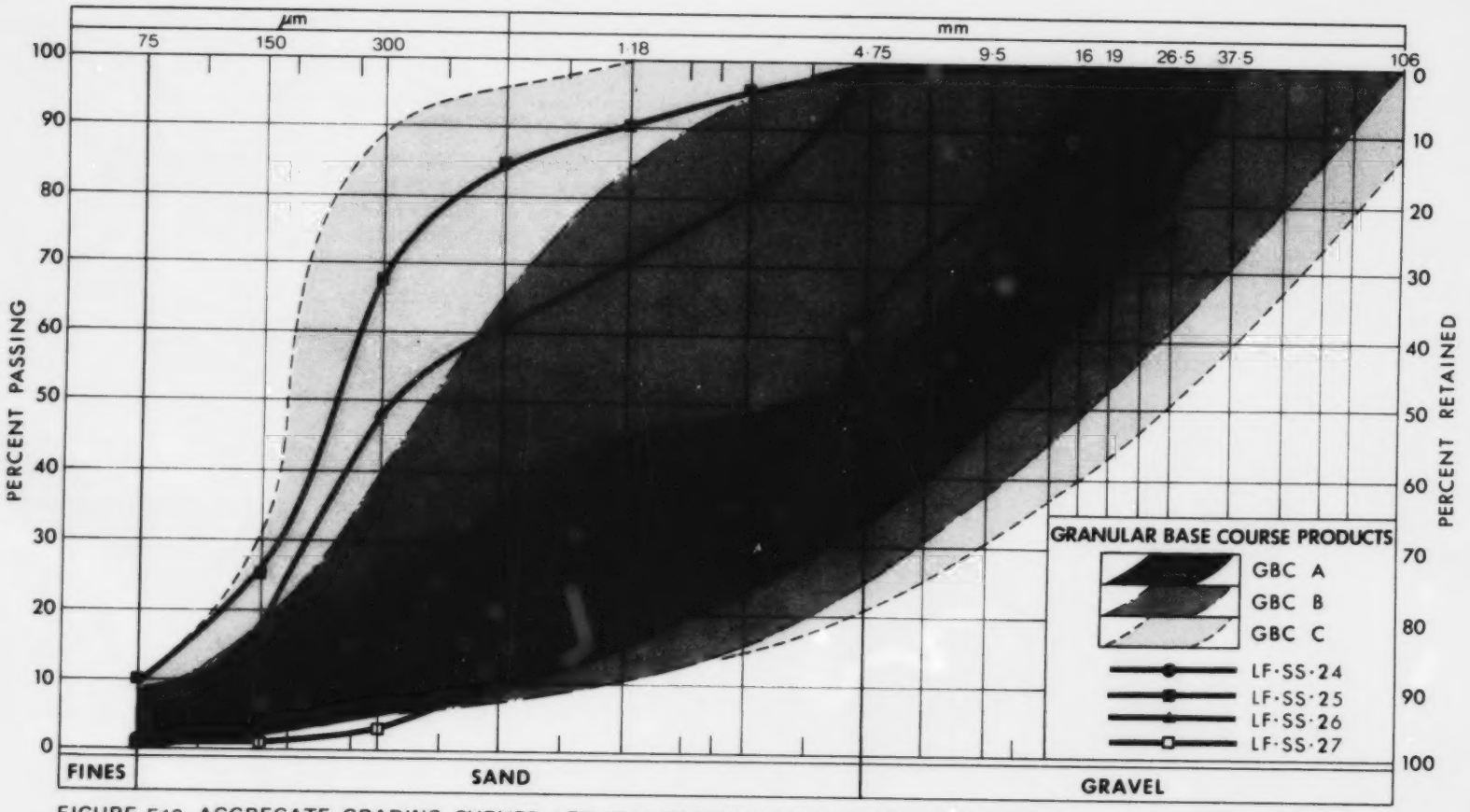


FIGURE E12: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

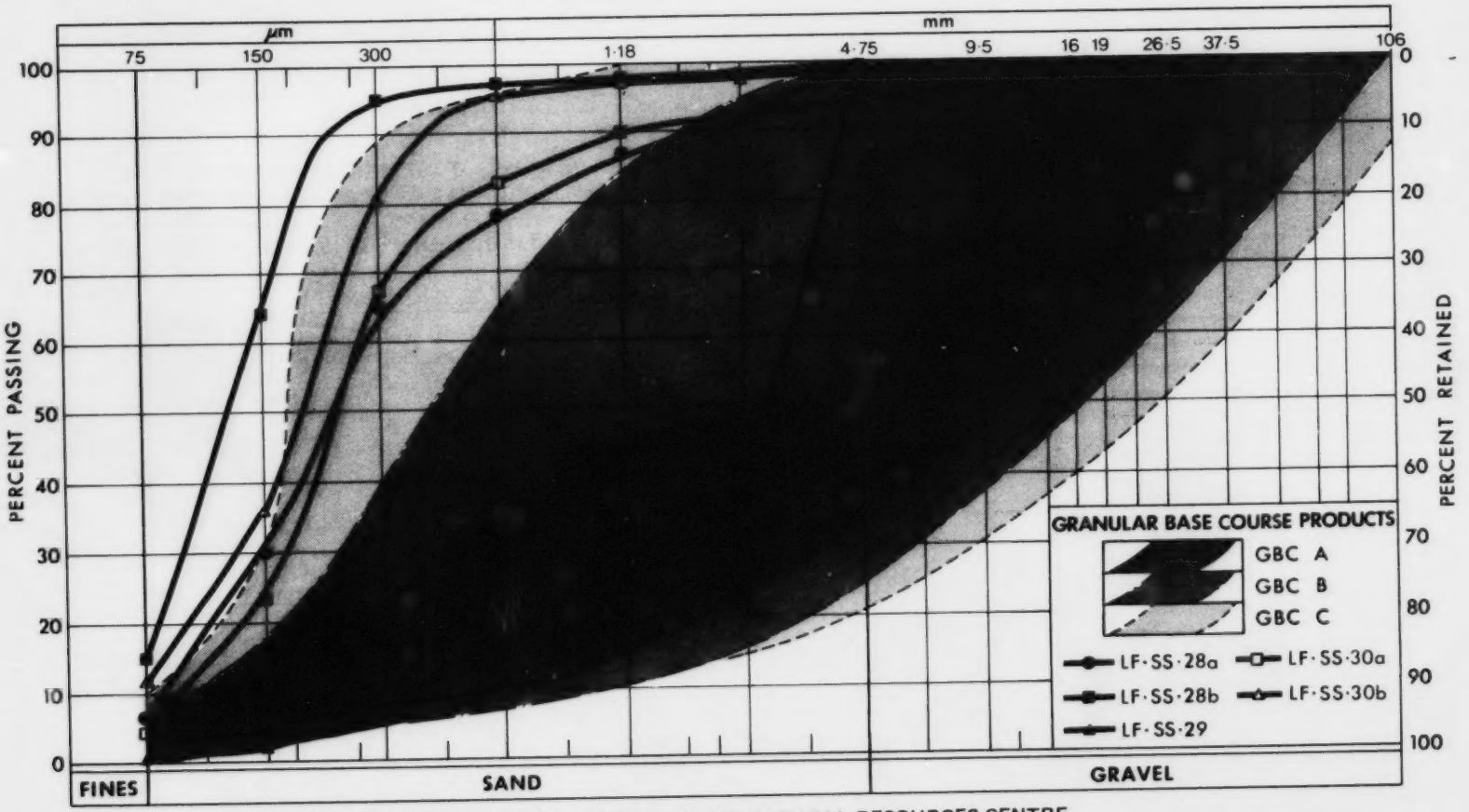


FIGURE E13: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

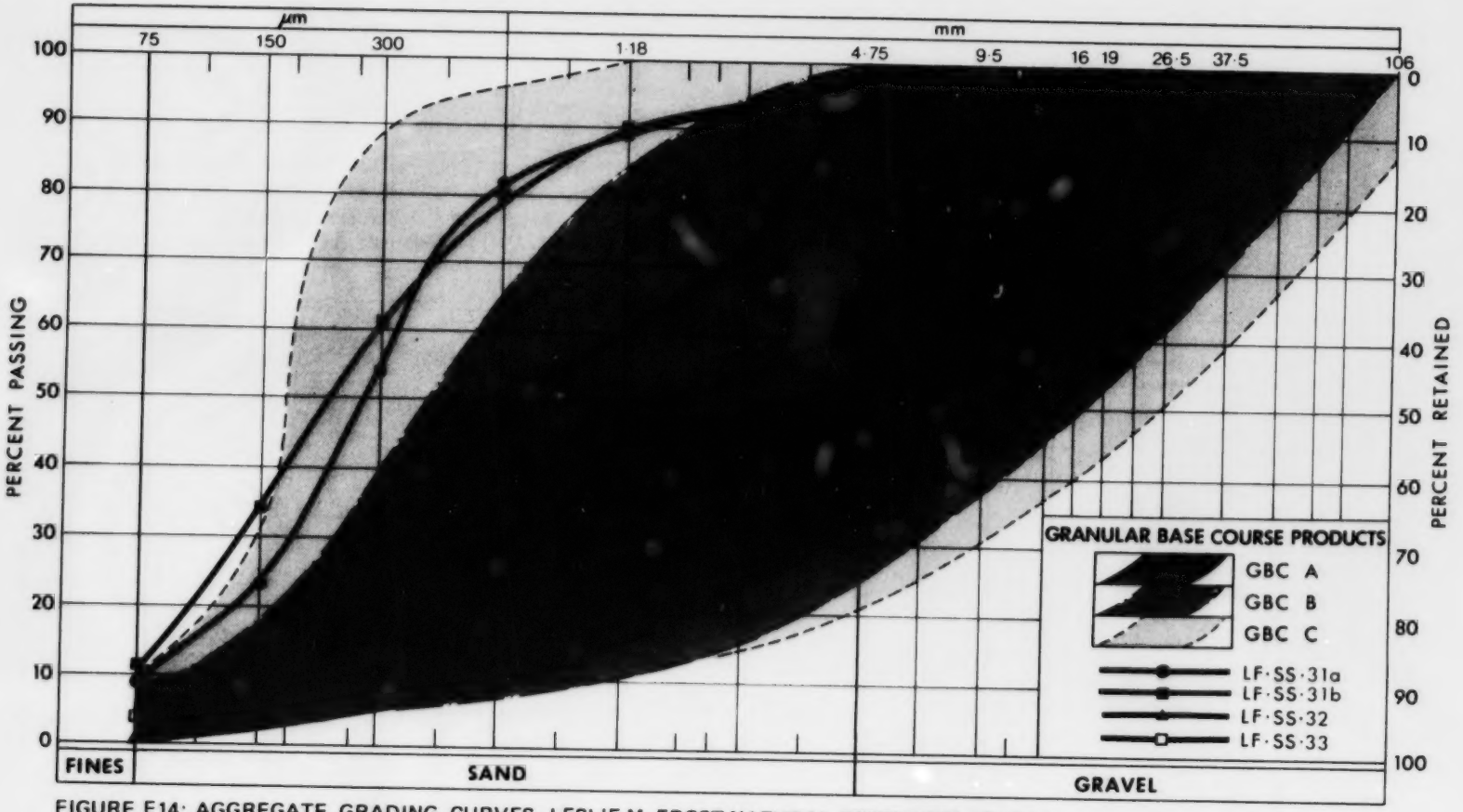


FIGURE E14: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

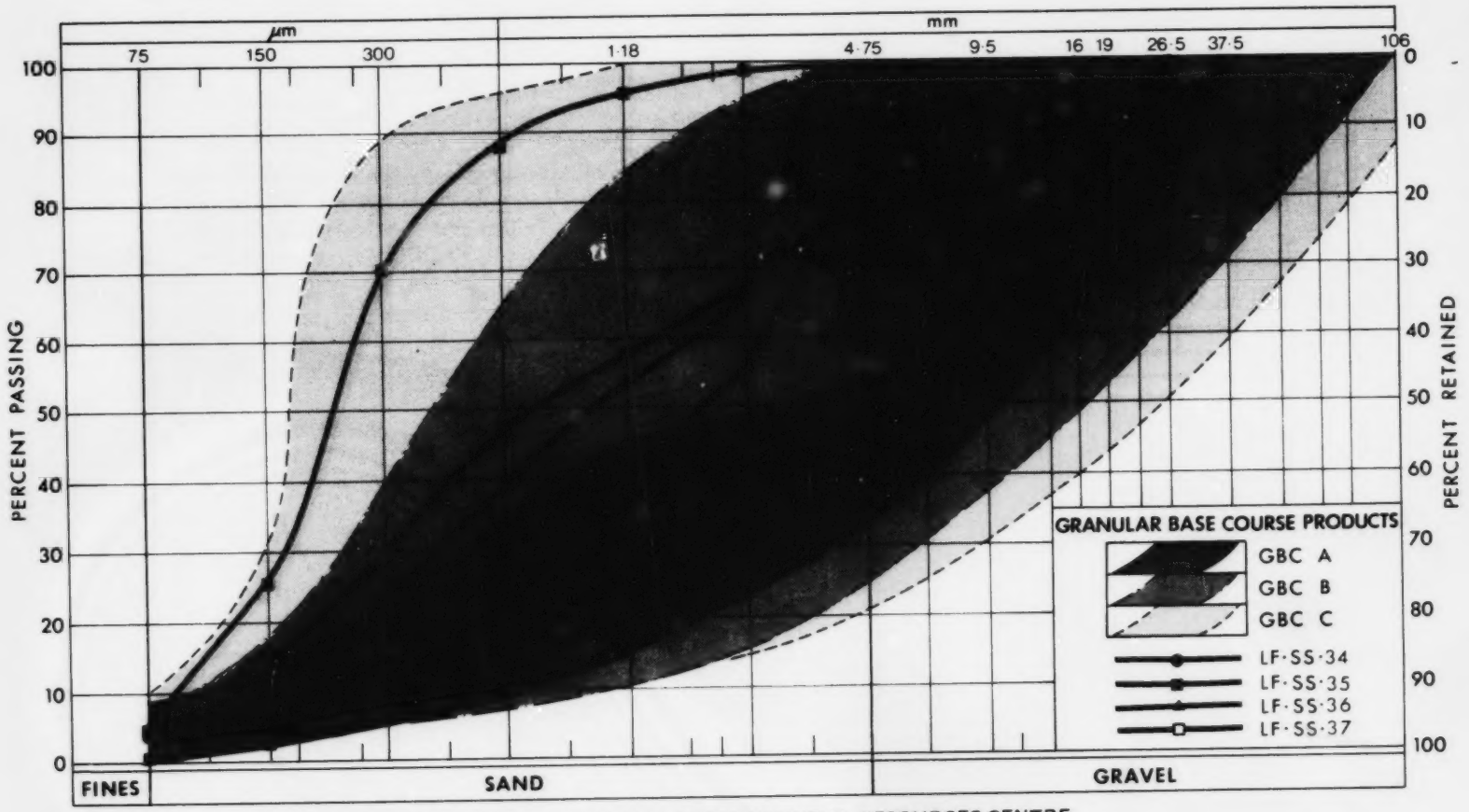


FIGURE E15: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

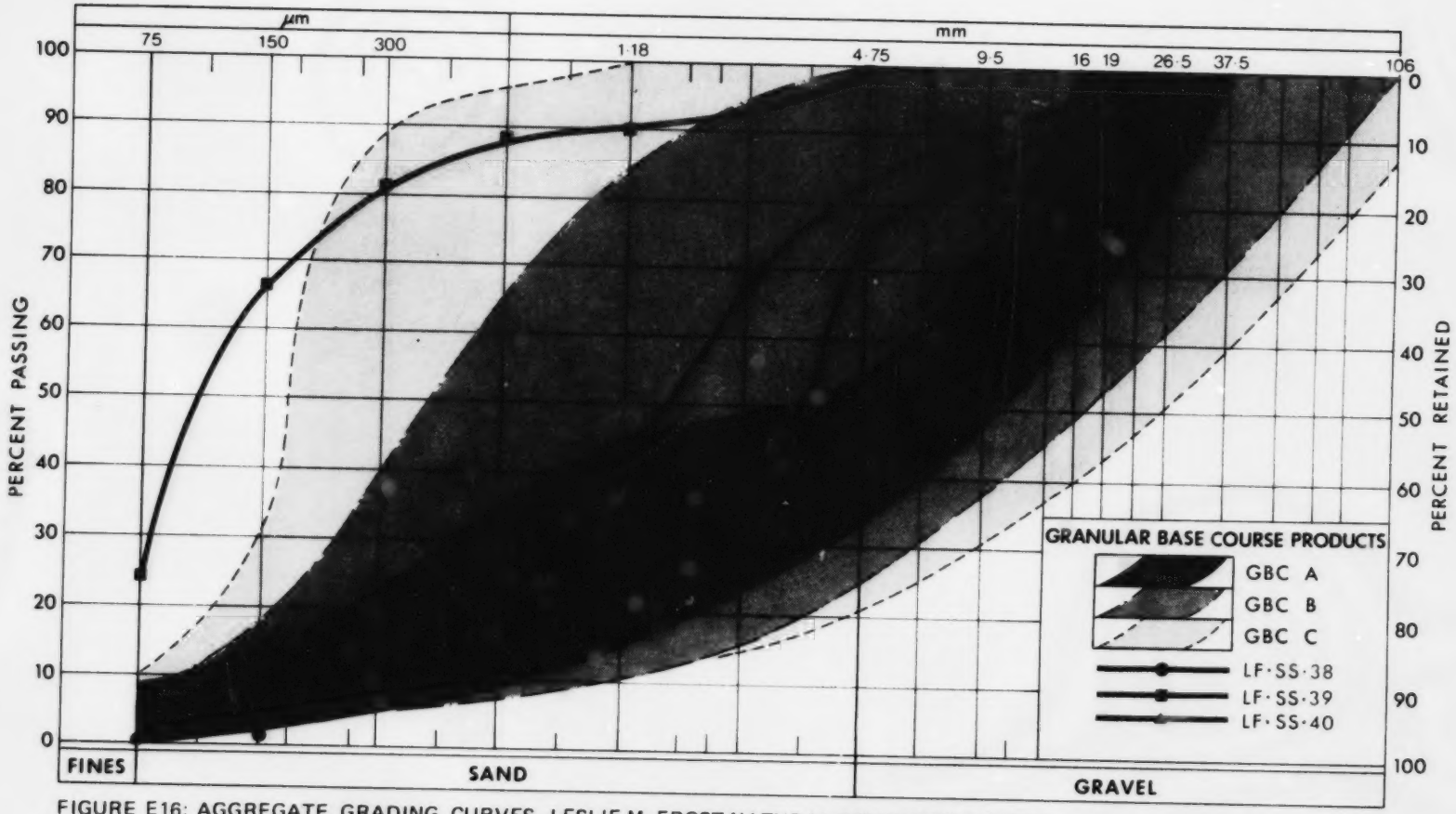


FIGURE E16: AGGREGATE GRADING CURVES, LESLIE M. FROST NATURAL RESOURCES CENTRE, (DORSET-EAGLE LAKE MAP AREA)

Based on analysis of the total aggregate contained in unprocessed samples taken by the staff of the Leslie M. Frost Natural Resources Centre (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.